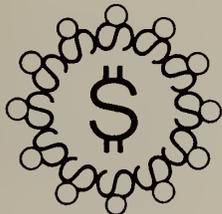




George J. Armstrong



Economics applied to standards: a guide to the literature

Stephen F. Weber
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Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
Washington, DC 20234

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Office of Engineering Standards
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U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, *Secretary*

Luther H. Hodges, Jr., *Deputy Secretary*

Jordan J. Baruch, *Assistant Secretary for Productivity, Technology, and Innovation*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

PREFACE

At the request of the Office of Standards Information, Analysis, and Development (OSIAD) of the National Bureau of Standards (NBS), a search of available literature on Benefit-Cost Analysis applied to standards was initiated in June 1978 by the Applied Economics Group of the NBS Center for Building Technology. This search covered case studies involving the evaluation of specific standards as well as literature on those segments of economic theory and methodology which could have direct application to standards evaluation. A preliminary draft of the results of this search was produced in November 1978. Additional funds were sought and obtained from the NBS Planning Office in order to complete the project. As a result, the subsequent issues of the Journal of Economic Literature were searched, and the relevant entries found in the 1978 search of the National Technical Information Service computer file were included along with a number of works suggested by the reviewers of the preliminary draft. In addition, extensive revisions were made to the annotations accompanying each bibliographical entry, the introduction and overview of the major findings provided in Part I were considerably revised and expanded, and an author index was added.

According to the Office of Management and Budget guidance on the FY 1979 NBS budget, "... NBS should conduct research and analysis to ... assess the economic impact of standardization." When economic analysis plays a role in the development and adoption of standards, more cost-effective decisions are likely to be made. Yet the useful literature on how economic analysis can be applied to standards is widely scattered and difficult to identify. Hence this guide will be useful to NBS researchers as well as to others interested in the standards area.

The authors would like to thank OSIAD and the Planning Office for sponsoring this project. Dr. Carol Chapman Rawie, formerly of OSIAD, was very helpful in providing guidance and sharing the results of her past research in the area. In addition, the authors are grateful to Dr. John S. McConnaughey for making available his unpublished bibliography on the valuation of human life. In the initial stages of this project, Elsie Cerutti provided invaluable technical assistance in conducting the computerized literature search. Also deserving special thanks are Bruce E. Thompson for editing several annotations, Anne S. Bretzfield and Stephen J. Roberts for finding a number of the entries, and Mary L. Ramsburg for typing the manuscript. For providing useful comments during the review process, the authors are grateful to Robert G. Atkins, Dr. Belinda L. Collins, Dr. Kenneth F. Gordon, Dr. Harold E. Marshall, Dr. John S. McConnaughey, Brian C. Pierman, Dr. Carol Chapman Rawie, and Dr. Mary Ellen Weber.

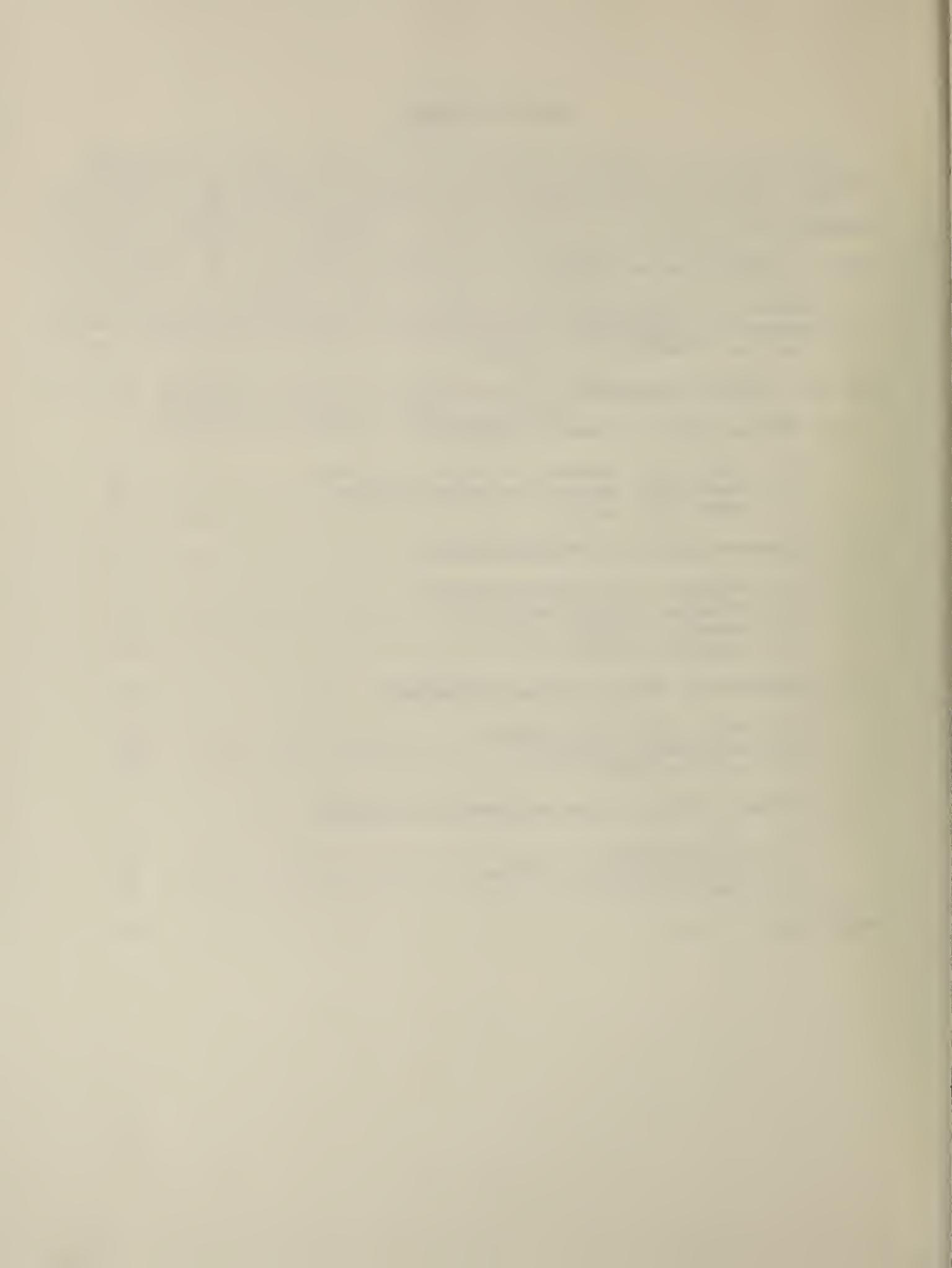
ABSTRACT

This report provides a guide to the available literature on the application of economics to the analysis of standards and standardization. One hundred eighty-nine relevant articles, reports, and books were found and organized into four major categories of interest: (1) General methods of economic evaluation; (2) Economics useful for standards analysis; (3) Evaluation of specific developed standards; and (4) Economics applied to the development of standards. The significant findings within each of these categories are briefly discussed in the text. The annotations which accompany the bibliographical entries provide more detailed information. The text includes a discussion of the approach followed in the literature search. An author index is also provided.

Key Words: Benefits; benefit-cost analysis; benefit-risk analysis; bibliography; costs; economics; evaluation; literature search; regulation; standards; standardization.

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PART I: INTRODUCTION AND OVERVIEW

1. Purpose and Scope

The purpose of this report is to offer a guide to the available literature on how economic analysis can be and has already been applied to the evaluation of standards. Guidance is provided by identifying 189 relevant works and organizing them into 13 distinct subcategories so that the reader can locate sources of interest by subject matter. Further guidance is given through the annotations which summarize the approaches and major findings of each entry. In addition, an author index is available at the end of the report to assist the reader in finding specific references.

The works identified here include case studies involving the evaluation of specific standards as well as literature on those aspects of economic theory and methodology that are relevant to the evaluation of standards. In the case studies, many different types of standards are evaluated. Some are mandatory standards issued by a regulatory authority, while others are voluntary standards developed and adopted by an industry, trade, or professional association. These standards address such public policy issues as environmental control, occupational and consumer product safety, fire hazards, and energy conservation, as well as such directly commercial concerns as efficient performance, reduction of unnecessary size variation for materials and parts, and improved accuracy of measurements.

The studies involving the economic evaluation of specific standards were found to follow either of two basic approaches: (1) evaluation of a single form or level of a proposed or existing standard; or (2) evaluations of alternative forms or levels as part of the standards development process, in order to help decide on the nature of the final standard. Although most evaluations are conducted for only a single version of a standard, considerable effort was made in this survey to find studies in which economic analysis was used in a standard's development to help choose among alternative versions of the same standard. Several interesting examples of the latter type were found.

Those areas of economic theory and methodology relevant to standards analysis include benefit-cost analysis for public and private investment decisions, benefit-risk analysis, the economics of safety, economic theories of (non-price) regulation, and methods to value human life.

2. Approach and Organization

The literature search was initiated by examining sources previously collected by the Office of Engineering Standards on the subject of voluntary standards and product certification. These sources have since been listed in Chapman, Bibliography on the Voluntary Standards System and Product Certification, NBSIR 79-1900, October 1979. A number of studies in this collection address economic issues and proved useful in suggesting other sources of information on economics applied to standards.

The Journal of Economic Literature, published by the American Economic Association, was also searched for references on economic theory relevant to

standards analysis. This quarterly journal surveys almost all of the significant economic and related journals, gives the tables of contents of all current issues, indexes articles by author and by subject category, and provides book reviews and article abstracts for the most noteworthy items. Although the subject category scheme does not have a specific heading devoted exclusively to the economics of standards, there are two categories which appear to cover the topic quite well. These are Category 613, "Public Utilities and Government Regulation of Other Industries in the Private Sector," and Category 920, "Consumer Economics; Levels and Standards of Living." A search was conducted of these two categories in the journal issues covering the past five years.

The National Bureau of Standards Library has available a useful computerized literature searching service, called DIALOG Information Retrieval Service. Four of the most promising data files accessible through this service were selected to be searched. A description of these data files in terms of subject coverage, type of documents included, and time period covered, follows.

PAIS INTERNATIONAL covers the whole range of the social sciences with emphasis on contemporary public issues and the making and evaluating of public policy. Worldwide in geographic scope, it lists publications in English, French, German, Italian, Portuguese, and Spanish. PAIS INTERNATIONAL is the machine-readable version of two hard copy indexes: PAIS Bulletin and PAIS Foreign Language Index. This computerized file provides broad coverage of the social sciences, including the following subjects relevant to the present study: (1) Economics; (2) Business; (3) Government; (4) Public Administration; and (5) Public Policy. PAIS INTERNATIONAL provides access to periodical articles, books, pamphlets, and Federal, state, and local government documents, as well as publications of public and private agencies, yearbooks, and directories published throughout the world. It indexes over 1,200 journals and 8,000 monographs per year. The PAIS Bulletin index begins in 1976, while the Foreign Language Index goes back to 1972.

SOCIAL SCISEARCH is an international, multidisciplinary index to the literature of the social, behavioral, and related sciences. This data base is prepared by the Institute for Scientific Information and corresponds to the printed Social Science Citation Index. SOCIAL SCISEARCH provides coverage of the most important worldwide social sciences literature. The relevant subjects covered by SOCIAL SCISEARCH include the following areas: (1) Communication; (2) Demography; (3) Law; and (4) Political Science. SOCIAL SCISEARCH indexes all significant items (articles, reports of meetings, letters, editorials, correction notices, etc.) from the 1,400 most important worldwide social sciences journals. Additional articles relevant to the social sciences are selected from 2,400 journals in the natural, physical, and biomedical sciences. The index covers material from 1972 to the present.

COMPREHENSIVE DISSERTATION ABSTRACTS is a definitive subject, title, and author guide to virtually every American dissertation accepted at an accredited institution since 1861, when academic doctoral degrees were first granted in the United States. Approximately 99 percent of all American dissertations are cited in this file. In addition, it serves to disseminate citations for

thousands of Canadian dissertations and an increasing number of papers accepted in institutions abroad. Professional (e.g., M.D., L.L.D.) and honorary degrees are not included. Individual, degree-granting institutions submit copies of dissertations or lists of dissertations completed to University Microfilms International (UMI). Citations for these dissertations are included in the data base and in the following UMI publications: Dissertation Abstracts International, American Doctoral Dissertations, and Comprehensive Dissertation Index. A complete listing of sources consulted in compiling this data base can be found in the preface to any volume of Comprehensive Dissertation Index. The subject categories most relevant to the present study are Business and Economics.

NTIS is an extensive data base consisting of government-sponsored research, development, and engineering reports plus analyses, journal articles, and translations prepared by Federal agencies, their contractors or grantees. This data base is produced and maintained by the National Technical Information Service of the U.S. Department of Commerce. NTIS also covers Federally generated machine-readable files and software as well as U.S. Government inventions available for licensing. It is the means through which unclassified, unlimited distribution reports are made available to the public. The NTIS data base includes material from both the physical and social sciences, including topics of immediate widespread interest, such as environmental pollution and control, energy conservation, technology transfer, health planning, societal problems, and urban and regional development and planning. The file covers the period from 1964 to the present.

The approach followed in all four of the computer file searches involved the specification of a strategy in which key words are used in combination to retrieve citations relevant to the topic. The basic strategy used was to combine two groups of key words: (1) one group relating to the subject matter of standards; and (2) the other group relating to the analytical approach of economics. Some of the key words used to represent the subject matter were: standard(s), standardization, test method, and testing. Some of the words used to signify the approach were: economic(s), benefit(s), cost(s), impact, effect, evaluation, and value. Once the two groups of key words used to signify the approach were entered, the file was searched for the intersection of the groups. That is, all citations with any combination of at least one key word from each group would be counted and then printed, if requested. For example, citations with the combined concepts, benefits of testing, costs of standardization, and the evaluation of standards, would all be counted. If the resulting count turned out to be unmanageably large, ways were sought to exclude possibly irrelevant combinations. One prominent example was the area of cost accounting standards.

A format was developed which would allow a consistent and comprehensive method for full citation of the bibliographical items found in the various searches. Each citation was written on a separate card allowing space for the individual annotations. Whenever possible, these annotations were excerpted from the abstract or executive summary of the reference. Abstracts of journal articles were sought either from the Journal of Economic Literature or from a copy of the article when available. Abstracts of government reports are often

printed directly in the report. These abstracts were used when a copy of the report was available. When abstracts were not available, an attempt was made to summarize the purpose, scope and conclusions of the study or book.

After analyzing the results of the literature search, a scheme was devised for categorizing the studies. There are four major categories: (1) General methods of economic evaluation; (2) Economics useful for standards analysis; (3) Evaluation of specific developed standards; and (4) Economics applied to the development of standards. A brief overview of the significant findings of each of these categories is presented in the next section. In referring to a particular bibliographical entry, a three-part numbering system is used in brackets. The first part refers to the major category number; the second part refers to the subcategory number within each category; and the third part refers to the alphabetical order within each subcategory. Thus, the full citation of an item designated by [2.3.7] can be found in the third subcategory of the second major category, and will be the seventh such item in alphabetical order. The annotated bibliography itself is presented in Part II, following the overview. At the end of the report is an index for locating references by name of author.

3. Overview of Annotated Bibliography

3.1 General Methods of Economic Evaluation [1.0]

The first major category, General Methods of Economic Evaluation, includes selected works in three basic areas: (1) Benefit-Cost Analysis for Private Decisions; (2) Benefit-Cost Analysis for Public Decisions; and (3) Benefit-Risk Analysis. Each area is discussed in turn.

Benefit-Cost Analysis for Private Decisions [1.1]. Benefit-Cost Analysis (also referred to as Cost-Benefit Analysis) is a general approach to capital budgeting decisions whereby the life-cycle benefits and costs of particular alternatives are considered and compared on a time equivalent basis. A variety of methods of comparison are used, such as the net present value, the net annualized value, the benefit-cost ratio, and the internal rate of return. This first subsection deals with Benefit-Cost Analysis as applied to investment decisions made by private individuals or firms. In these analyses benefits and costs are included only to the extent that they affect the financial position of the private individual or business enterprise. Typical practice in such studies would be to measure cash flows on an after-tax basis. A number of texts are available describing Engineering Economy, which is a type of Benefit-Cost Analysis often applied to industrial investment decisions. Grant *et al.* [1.1.4] is a widely used text and reference work on this technique. Two recent works on Engineering Economy containing many numerical examples are Newnan [1.1.6] and a comprehensive guidebook produced by American Telephone and Telegraph [1.1.1].

Two other recent works are designed to provide the noneconomist with a good introduction to Benefit-Cost Analysis. Anderson and Settle [1.1.2] cover both the theory and practice of the method as well as techniques for collecting cost and benefit data. Sugden and Williams [1.1.7] focus primarily on applying the method and offer many practical examples. Another work addressed to the

noneconomist illustrates the principles of applying Benefit-Cost Analysis to the evaluation of energy conservation investments in buildings: Marshall and Ruegg [1.1.5].

Benefit-Cost Analysis for Public Decisions [1.2]. This second subsection deals with Benefit-Cost Analysis as applied to public investment and policy decisions. In these analyses, an attempt is made to include all benefits and costs and to measure them from the public or social point of view. Prest and Turvey [1.2.10] offer an excellent, though somewhat dated, literature survey of this type of Benefit-Cost Analysis. An extensive collection of more recent literature on the method applied to public policy evaluation is available from the Aldine Publishing Company [1.2.1]. Mishan [1.2.8] offers a comprehensive presentation of social Benefit-Cost Analysis, intended primarily for economists. Dasgupta and Pearce [1.2.2] discuss theoretical problems (e.g., distribution effects and uncertainty) often encountered in applying this type of analysis. A critical overview of the method is presented in Fischhoff [1.2.3], while Luft [1.2.6] argues that the implementation phase of public policy should be included in these analyses. The special problem of selecting an appropriate rate of discount for public policy analysis is treated in Mikesell [1.2.7] and the U.S. Office of Management and Budget [1.2.12]. Two works that illustrate how Benefit-Cost Analysis should be applied to specific public decisions are: Peskin and Seskin [1.2.9] for evaluating water pollution policy, and Ruegg et al. [1.2.11] for selecting energy conservation investments in public buildings.

If the benefits of a public investment or policy decision cannot be valued in dollar terms, either they are assumed to be equal for the alternatives being considered or the costs (net of any dollar-valued benefits) are denominated in terms of cost per unit benefit. This approach, called Cost-Effectiveness Analysis, is often used in evaluating military investment alternatives as illustrated in Goldman [1.2.4]. The method can also be employed to avoid the necessity of placing a dollar value on human life, as was done in a case study conducted by McConnaughey [3.3.14].

Benefit-Risk Analysis [1.3]. When the consequences of investment decisions involve the degree to which the probability of an accident or catastrophe has been reduced, the technique of Benefit-Risk Analysis is used. A comprehensive bibliography on this method has been collected by Clarke and Van Horn [1.3.1]. One section of this work lists citations dealing specifically with standard setting. The Committee on Public Engineering Policy of the National Academy of Engineering [1.3.2] has published a useful collection of papers on Benefit-Risk Analysis. Rowe [1.3.7] provides a thorough discussion of the nature of risk, its valuation, and methods of risk analysis and decision making under uncertainty. In his classic collection of theoretical lectures, Raiffa [1.3.6] argues that preferences for uncertain outcomes be scaled in terms of utility values and the likelihood of each outcome be assigned a subjective probability. Lowrance [1.3.4] offers nontechnical approaches to risk policy problems and includes a discussion of how safety standards are developed. In a widely cited article, Starr [1.3.8] analyzes public acceptance of personal risks arising from technological developments. Fischhoff et al. [1.3.3] analyzes the relationships between perceived risk, acceptable risk, and perceived benefit for 30 activities and technologies. Risk assessment methods are

applied to nuclear power plants in the well known U.S. Atomic Energy Commission study directed by Rasmussen [1.3.9].

3.2 Economics Useful for Standards Analysis [2.0]

The second major category, Economics Useful for Standards Analysis, includes economic research which has been or could readily be applied to the study of standards. This research is divided into four subcategories: (1) Economics of the Standards System; (2) Economics of Regulation; (3) Economics of Safety and Health; and (4) Valuation of Human Life.

Economics of the Standards System [2.1]. This subsection deals with studies that address economic issues arising from the standards system or standardization in general. One of the most comprehensive economic studies of the U.S. voluntary standards system is by Hemenway [2.1.8]. Another work by Hemenway [2.1.9] provides an overview of the voluntary standards systems in Canada, the United Kingdom, West Germany, and Denmark. Chapman [2.1.4] discusses how Benefit-Cost Analysis can be applied by standards developing organizations in allocating research funds and planning standards programs. Another work that could be helpful in such applications is by Scherer [2.1.19]. An article by Toth [2.1.23] describes the development of a standard which specifies a method for estimating the economic value of standardization efforts. In Phucas [2.1.14] a conceptual framework for the economic evaluation of standards is presented and applied to several areas of international standards activity of the National Bureau of Standards. This work also contains a supplementary section which reviews a number of works on the economics of standardization. Matuura [2.1.11] proposes a logarithmic equation for estimating the cost savings resulting from standardization. A study by Settle and Weisbrod [2.1.20] analyzes the conditions under which mandatory standards are more equitable and/or economically efficient than alternative government policy instruments such as taxes and public information programs.

Two studies have been conducted on economic effects of measurement systems: Crane [2.1.5] and Poulson [2.1.15]. A study by the U.S. Federal Trade Commission [2.1.25] analyzes industry standardization and certification programs. The role of seals and certifications of approval in consumer decision making is examined by Parkinson [2.1.13]. Hearings were conducted by the House of Representatives on the effects of voluntary standards on small businesses [2.1.24]. In the 1950's, the American Standards Association published two general studies on the benefits and costs derived from industry standards: [2.1.1] and [2.1.2].

Economics of Regulation [2.2]. Over the past decade economists have been developing a framework for analyzing public regulation of economic activity. Although most of this literature is addressed to the regulation of prices (i.e., tariffs, fares, and utility rates), much of it is applicable to the regulation of non-price characteristics of goods and services such as is accomplished through mandatory standards. Probably the most comprehensive treatment of the economics of regulation is contained in Alfred Kahn's two-volume work [2.2.5]. The major articles on the general theory of regulation are by Stigler [2.2.12], Posner [2.2.8], and Peltzman [2.2.7]. The discussions in these articles of how coalitions are formed among diverse interest groups

may be relevant to the process of developing voluntary standards in the private sector.

An excellent collection of papers on the economic effects of regulating the quality and variety of products has been edited by Caves and Roberts [2.2.2]. A paper by Colantoni et al. [2.2.4] presents a framework for evaluating the economic welfare effects of two types of regulation: information requirements and restrictions on product types. Pustay [2.2.9] examines the question of whether economic inefficiencies result in industries which are regulated. Schmalensee [2.2.11] provides an economic rationale for regulating the durability of consumer goods in non-competitive industries.

Economics of Safety and Health [2.3]. A recent review of the literature on the economics of safety may be found in Canada and Ayoub [2.3.5]. Another review was published on alternative decision methodologies for evaluating regulatory action affecting health and safety by Hendrickson et al. [2.3.12]. Several articles have been written on how to achieve the optimal balance between safety and the cost of achieving alternative levels of safety: Spengler [2.3.19]; Brown [2.3.2]; and Cannon [2.3.6]. The general problem of the cost of safety regulation has been reviewed by Cornell et al. [2.3.7], Oi [2.3.17], and Lave [2.3.14]. The specific area of product safety has received some attention from several noted economists: Grabowski and Vernon [2.3.11] and Oi [2.3.18]. A number of studies have been conducted which apply economic analysis to particular safety provisions, such as, aviation safety by Fromm [2.3.9], transportation safety by Lave [2.3.15] and Blomquist [2.3.1], and food safety by Campbell [2.3.4].

Valuation of Human Life [2.4]. Economic analyses of standards involving health and safety frequently confront the problem of placing a value on human life. The literature in this area is quite extensive and some of it has been collected recently in the Clarke and Van Horn bibliography [1.3.1] referred to above. One of the most comprehensive treatments of the subject can be found in Jones-Lee [2.4.8]. In his book on Benefit-Cost Analysis, Mishan [1.2.8] presents an excellent survey of alternative methods of valuing life. One of the earliest works on the subject is by Schelling [2.4.14]. The two most widely used approaches to valuing human life are the willingness-to-pay approach and the discounted lifetime earnings approach (sometimes called the human capital approach). The former measure is viewed by most economists as being theoretically correct, while the latter is easier to carry out in practice. Mishan [2.4.11] offers the clearest exposition of the theoretical superiority of the willingness-to-pay approach. Acton [2.4.1] demonstrates how this approach can be used to evaluate a public program designed to reduce the risk of death from heart attacks. Bailey [2.4.3] uses consumer choices between safety and insurance to establish a theoretical relationship between the two approaches to valuing lives. Conley [2.4.4] shows that discounted lifetime earnings could serve as a lower bound measure of willingness-to-pay under certain restrictive assumptions. Linnerooth [2.4.9] provides a detailed review of several models which imply a theoretical relationship between the two approaches.

Several general articles have been written to introduce noneconomists to the alternative techniques for valuing human life: Hayzelden [2.4.7],

Zeckhauser [2.4.16], and Rhoads [2.4.13]. Several case studies have been conducted to estimate the value of life: by Ghosh et al. [2.4.6] using highway speed data; by Thaler and Rosen [2.4.15] using employment data; by Needleman [2.4.12] using kidney transplant data; and by Melinek [2.4.10] using data on pedestrian injuries, smoking, and employment.

3.3 Evaluation of Specific Developed Standards [3.0]

The third major section, Evaluation of Specific Developed Standards, deals with economic studies conducted to evaluate particular standards that have already been developed. This type of evaluation occurs after the fact and does not involve the integration of economic analysis into the actual standards development process. Such evaluations either compute the costs, the benefits, or both costs and benefits which result from the use of the particular standard in question. The many different types of standards that have been evaluated are grouped here into three subcategories: (1) Safety and Health Standards; (2) Environmental Standards; and (3) Other Standards.

Safety and Health Standards [3.1]. Before proceeding to specific safety and health standards which have been evaluated, several studies describing approaches to evaluating these standards should be mentioned. A framework for evaluating occupational health and safety standards is developed and applied to the Federal asbestos dust standard in a dissertation by Settle [3.1.18]. A theoretical model for examining the economic effects of the Occupational Safety and Health Act of 1970 is presented by Pachauri [3.1.13]. The applicability of Benefit-Cost Analysis to evaluating product safety standards is discussed and illustrated in Dardis et al. [3.1.4]. Methods of designing sampling plans for effecting compliance with safety standards are discussed in Broussalian et al. [3.1.3], and the problem of measuring risk in evaluating safety standards is treated in Broussalian [3.1.2].

Case studies of several specific safety and health standards (e.g. venting of aerosol cans, tempered glass for windows, and rotary lawn-mowers) are discussed in a staff report by the National Commission on Product Safety [3.1.12]. Quite a number of studies can be found which evaluate auto standards: Peltzman [3.1.15], Pennington and Bouland [3.1.16], the U.S. General Accounting Office [3.1.19], and Wu [3.1.21]. Another group of studies concerns the economic effects of consumer protection legislation on the pharmaceutical industry: Grabowski and Vernon [3.1.6], Grabowski et al. [3.1.7], and Peltzman [3.1.14]. Other safety and health standards that have been evaluated include one for cotton dust by Research Triangle Institute [3.1.17], and for miners and asbestos workers in Canada by Doern [3.1.5].

Environmental Standards [3.2]. Within the past decade the literature on the economics of the environment has been rapidly growing. Much of the literature focuses on the use of financial incentives (taxes, subsidies, effluent charges, etc.) to control pollution. Nevertheless, there are a number of economic studies which deal with the use of standards to protect the environment. Perhaps the most useful introduction to the subject is the survey of environmental economics literature by Fisher and Peterson [3.2.5]. A theoretical article on how a system of standards combined with a set of effluent charges

can be used to achieve a specified reduction in pollution levels at minimum cost was written by Baumol and Oates [3.2.1]. Another article by Maler [3.2.12] discusses a framework for deriving the willingness-to-pay for certain public goods such as clean air or water.

Several works are helpful for actually evaluating the economic effects of environmental standards. Chugh et al. [3.2.3] examine the impact of pollution control legislation on the market risk of securities. Lave and Seskin [3.2.9] derive quantitative estimates of air pollution effects on various diseases and of the dollar benefit of pollution abatement. The National Academy of Sciences [3.2.13] has published a guide for decision making concerning the regulation of chemicals in the environment. A number of studies analyze the relationship between energy use and environmental standards: Harrison [3.2.6], Lievano [3.2.10], Schlottmann [3.2.15], and Watson and Downing [3.2.17]. Two other studies concern the income-distribution effects of environmental standards: Dorfman and Snow [3.2.4], and Harrison [3.2.7]. The economic effects of certain noise standards are evaluated in both Kearney [3.2.8] and Plager et al. [3.2.14]. There is even an economic analysis of a safe minimum standard for endangered species: Bishop [3.2.2].

Other Standards [3.3]. A wide variety of standards besides those addressed to safety, health, and environmental concerns have been subjected to economic analysis. A great deal of this research is related directly or indirectly to the building industry. In 1964, Fisher [3.3.5] conducted a study sponsored by the National Bureau of Standards to assess the economic impact of a standard for softwood lumber. Two studies were published by Lentz [3.3.8 and 3.3.9] and one by Little [3.3.11] on the economic impacts of the ASHRAE 90-75 Standard for energy conservation in building design. In another study, Little [3.3.10] assessed the economic impact of HUD's Minimum Property Standards to cover all new residential construction. Similar studies have been conducted on the economic effects of building codes, which are often based on standards. A method of evaluating building code impacts has been developed and applied by McConnaughey [3.3.14 and 3.3.15] to the 1975 National Electrical Code requirement for ground fault circuit interrupters in residences. Marshall et al. [3.3.13] have investigated the cost savings attributable to using reduced-sized venting for the protection of the traps of plumbing fixtures.

Economic analyses of standards unrelated to buildings have been conducted as well. Several studies relate to the computer industry: Fiorello and Jaffin [3.3.4]; Slome [3.3.20]; and the U.S. Department of Commerce [3.3.21]. The cost-effectiveness of medical device standards was studied by Miller [3.3.16]. Standards for plant designs for nuclear power plants are discussed by Kennedy and Morse [3.3.7]. The U.S. National Highway Traffic Safety Administration studied automotive fuel economy standards [3.3.22]. The economic impact metrication would have on commercial weights and measures activities was investigated by Hatos [3.3.6]. Bucklin [3.3.3] and the National Center for Productivity and Quality of Working Life [3.3.18] have conducted studies on standards for grading tires.

3.4 Economics Applied to the Development of Standards [4.0]

The studies included in the fourth section, Economics Applied to the Development of Standards, differ from those of the previous section in the manner in which the economic analysis relates to the standards development process. The standards studied in the third section citations were already developed before the economic analysis was conducted. In the studies cited below, on the other hand, economic analysis was used to determine the optimal level of the standard in question. These studies fall into three subcategories, according to the type of standard analyzed: (1) Fire Standards; (2) Energy Conservation Standards; and (3) Other Standards.

Fire Standards [4.1]. Two studies have been conducted on flammability standards for children's sleepwear. A report by Crow [4.1.4] provides a decision analysis framework for setting the level of the standard. A more recent study by Smith and Dardis [4.1.8] employs Benefit-Cost Analysis in the evaluation of the 0-6X Children's Sleepwear Standard. The proposed upholstered furniture standard of the Consumer Product Safety Commission is analyzed by Helzer *et al.* [4.1.6] using decision analysis and by Dardis and Thompson using Benefit-Cost Analysis [4.1.5]. These two methodologies could be applied to other flammability standards as well. Three publications by Chapman [4.1.1] and Chapman *et al.* [4.1.2 and 4.1.3] describe an application of linear programming to determine the least-cost means of achieving compliance with the Life Safety Code in health care facilities. Another study involving the use of economic analysis for optimizing fire safety measures is by Lie [4.1.7].

Energy Conservation Standards [4.2]. An overview of the economic efficiency considerations that can be incorporated into the development of energy conservation standards for buildings is presented in Marshall and Petersen [4.2.3]. Another report by Petersen [4.2.5] demonstrates in detail how differences in building type, climate, energy cost, and operational requirements can be directly included in the standards development process. An article by Marshall and Ruegg [4.2.4] includes a discussion of energy conservation standards based on Life-Cycle Cost Analysis. Residential insulation standards are developed for Vermont using an economic optimization model in a report by Heim [4.2.1]. The question of the proper value for energy to be used in the development of optimal energy conservation performance standards for new buildings is addressed by Weber [4.2.8 and 4.2.9]. These two studies recommend the use of the marginal social value of energy rather than its price in the determination of optimal standards. Hirst and Carney [4.2.2] use a simulation model of energy consumption in residences to assess the direct economic effects of thermal standards for new construction. One very successful example of applying economic analysis to energy related standards is a study of the 1000-hour standard for the life of electric bulbs in the United Kingdom. Prais [4.2.6] derives an optimization rule for the light bulb life which shows that 1000 hours is generally too short a life and that the optimum life varies with bulb wattage.

Other Standards [4.3]. Economic methods have been used to determine the optimal level for standards outside the areas of fire safety and energy conservation. Much of this research is in the environmental field. Hyden [4.3.4] determines the optimal economic wastewater treatment standards for individual users in a

river basin. Stollman et al. [4.3.6] conduct an economic impact analysis of anticipated hazardous waste regulatory standards. Voornees and Associates [4.3.7] develop a cost-effectiveness methodology for evaluating transportation control strategies as a means of achieving ambient air quality standards. Other environmental standards studied are those for groundwater quality [4.3.3] and for automotive emissions [4.3.5].

Two reports published by the National Bureau of Standards concern the building and construction industry. Chapman and Colwell [4.3.1] develop a methodology for determining the economic efficiency of draft standards to provide protection against the progressive collapse of buildings. Clark and Roat [4.3.2] present a bibliography on the impact of metrication and dimensional coordination on the construction industry.

Having completed the overview of the major findings within each subcategory, we now turn to Part II, which presents each bibliographic entry along with its annotation. The items are arranged in alphabetical order within each category.

PART II: ANNOTATED BIBLIOGRAPHY

1.0 GENERAL METHODS OF ECONOMIC EVALUATION

1.1 Benefit-Cost Analysis for Private Decisions

- 1.1.1 American Telephone and Telegraph Company. Engineering Economy: A Manager's Guide to Economic Decision Making. 3rd ed. New York: McGraw-Hill Book Company, 1977, 516 pp.

The stated purpose of this comprehensive text is to provide the manager with guidelines for dealing with the economic choice among alternatives involving various amounts of capital expenditures, expenses, and revenues. The material is in three sections: five background chapters on accounting, financing, and the nature of costs; four chapters on the capital costs associated with an investment; and six chapters on techniques of structuring an actual economic analysis. This edition has been enlarged and brought up to date.

- 1.1.2 Anderson, Lee G. and Settle, Russell Franklin. Benefit-Cost Analysis: A Practical Guide. Lexington, Mass.: Lexington Books, 1978.

This book provides a brief, but thorough, introduction to the theory and practice of benefit-cost analysis. Two basic objectives are accomplished: (1) to provide an understanding of the theoretical foundations of benefit-cost analysis; and (2) to demonstrate the application of benefit-cost analysis in realistic (and less-than-ideal) situations. Typical of such situations are those involving incomplete data or time and budget constraints. In addition to the usual treatment of discounting and decision rules for project selection, there is considerable discussion of methods for collecting cost and benefit data. The intended audience includes both economics students as well as those with little or no formal training in economics. An extensive bibliography is included.

- 1.1.3 Dewhurst, R. F. J. Business Cost-Benefit Analysis. London: McGraw-Hill Book Company (UK) Limited, 1972, 288 pp.

This study begins by considering existing social benefit-cost techniques and then applies them, where appropriate, to the business situation. The largest chapter in the book is devoted to providing an adequate mathematical background. The author's main aim is to try to place money values on those

benefits which have hitherto been thought unquantifiable. This permits both costs and benefits to be expressed in money terms so that a meaningful comparison of all factors can be made.

- 1.1.4 Grant, Eugene L., Ireson, W. Grant, and Leavenworth, Richard S. Principles of Engineering Economy. 6th ed. New York: John Wiley & Sons, 1976, 624 pp. Includes 4 pages of bibliographical references.

This comprehensive text explains the principles and techniques needed for making decisions about the acquisition and retirement of capital goods. The major focus is on decisions made in the context of a private firm with a goal of maximizing profits. The effects of taxes, inflation, and the cost of financing on the outcome of capital budgeting decisions are considered in depth. This text is useful not only for engineering students but also for students of economics, accounting, finance, and management. This book also can serve as a working manual for engineers, management personnel, and others whose duties require them to make decisions about investments in capital goods.

- 1.1.5 Marshall, Harold E.; Ruegg, Rosalie T.; and Wilson, Forrest. Simplified Energy Design Economics: Principles of Economics Applied to Energy Conservation and Solar Energy Investments in Buildings. National Bureau of Standards Special Publication 544. Washington, D.C.: U.S. Government Printing Office, 1980.

The goal of this book is to provide a guide to basic economic concepts and tools for solving simple economic problems in energy conservation. Principles and step-by-step examples are included as aids in determining the economic efficiency of specific energy investments. The book is intended as an adaptable instrument for the design community: architects, engineers, builders, building owners and managers, codes and standards writers, government policy makers, and students of these disciplines. The emphasis is on practical method rather than theoretical discussion.

- 1.1.6 Newnan, Donald G. Engineering Economic Analysis. Revised Edition. San Jose, Calif.: Engineering Press, 1977, 469 pp. Includes 3 pages of bibliographical references.

This book is designed to teach the fundamental concepts of engineering economy to engineering students. Over 130 example problems are provided together with detailed solutions. Economic analysis methods (present

worth, rate of return, etc.) are examined in detail. A rigorous analysis is provided with special attention given to the restrictions and limitations of each method. Such special topics as the effects of inflation and the application of computers are discussed. There is a full (1/4% to 60%) and conveniently organized set of compound interest tables at the back of the book. The result is a modern and complete presentation of engineering economic analysis techniques applicable to the evaluation of standards.

- 1.1.7 Sugden, Robert and Williams, Alan. The Principles of Practical Cost-Benefit Analysis. New York: Oxford University Press, 1978, 288 pp.

This introduction to the practice of benefit-cost analysis is geared to the needs of both the non-economist and the economist. After a discussion of financial appraisal, the distinguishing features of benefit-cost analysis are introduced progressively. Practical examples are used whenever possible and economic theory is introduced only where it is immediately relevant to practice. Appendices which relate the ideas of the book to the mainstream economic theory and comprehensive guides to further reading have been included for the experienced economist.

1.2 Benefit-Cost Analysis for Public Decisions

- 1.2.1 Aldine Publishing Company. Benefit-Cost and Policy Analysis: An Aldine Annual on Forecasting, Decision-Making, and Evaluation. Chicago, 1972-1975, 4 volumes on an annual basis. Includes bibliographical references.

Each volume of Benefit-Cost and Policy Analysis presents a selection of important works on the subject that appeared in the previous year. The articles selected reflect the several main trends in this field of study as well as its general scope and breadth. They are intended to contribute to an understanding of the way policy analysis ought to be conducted. Specific topics covered by the papers include the following: judgment under uncertainty, public policy alternatives for energy conservation and pollution control, environmental protection and income distribution, the theory of marginal public expenditure choices, and principles for policy and program analysis.

- 1.2.2 Dasgupta, Ajit K. and Pearce, D. W. Cost-Benefit Analysis: Theory and Practice. New York: Barnes and Noble Books, 1972, 270 pp. Includes 170 bibliographical references.

Benefit-cost analysis is an attempt to devise a formal system of rules whereby the social worth of a policy can be judged. This book analyzes this system of rules and shows that they are essentially equivalent to the prescriptive rules derived in the theory of welfare economics some thirty years ago. The authors investigate the limitations of these rules against the background of subsequent developments in welfare theory. The distributional effects of investment decisions are considered in addition to the efficiency effects. The problems of risk and uncertainty, the selection of a social rate of discount and an appropriate decision rule are all thoroughly discussed. Two case illustrations are provided.

- 1.2.3 Fischhoff, Baruch. "Cost-Benefit Analysis and the Art of Motorcycle Maintenance." Policy Sciences, Vol. 8 (1977), pp. 177-202.

Partially as the result of consumer and environmentalist pressure, proposals for large-scale government and private projects are increasingly coming under the scrutiny of benefit-cost analysis, decision analysis, risk assessment and related approaches. This paper presents a critical overview of such analyses. It discusses their rationale, their acceptability as guides to decision making, the problems they encounter, their possible misuses, and steps needed to increase their contribution to society. The discussion is illustrated with a variety of examples, based on the evaluation of new technologies.

- 1.2.4 Goldman, Thomas A., ed. Cost Effectiveness Analysis: New Approaches in Decision Making. New York: Frederick A. Praeger, Publishers, 1967, 231 pp.

This work is a collection of 13 papers presented at a symposium on cost-effectiveness analysis sponsored by the Washington Operations Research Council. Although most of these papers deal with applications to the area of defense procurement, the method of cost-effectiveness analysis is well illustrated. The method is appropriate for investment decisions whose benefits cannot be valued in dollar terms. Such situations frequently arise in the context of public investment decisions.

- 1.2.5 Harberger, Arnold C. Project Evaluation: Collected Papers. Chicago: Markham, 1973, 330 pp.

This book contains eleven articles published between 1964 and 1972 on the theory of benefit-cost (b-c) analysis and its application to project evaluation. They survey a wide range of activities to which b-c techniques may be applied. The essays provide a summary of some of the principal issues involved, as well as of the references to b-c analysis for students examining project evaluation. The issues include the choice of the correct discount rate, the social opportunity cost of public funds, the rate of return to private capital, and the social opportunity cost of labor. Practical evaluations of electricity, irrigation, transportation and education projects are presented as well.

- 1.2.6 Luft, Harold S. "Benefit-Cost Analysis and Public Policy Implementation: From Normative to Positive Analysis." Public Policy, Vol. 24, No. 4 (Fall 1976), pp. 437-462. Includes 35 bibliographical references.

Benefit-cost analysis and the closely related cost-effectiveness analysis are techniques designed to assist the public decision maker in choosing from among various alternative projects or policies. These tools are used to help identify the socially beneficial alternatives and thus are used in a normative way to indicate what should be done. It is becoming increasingly apparent that this is only the first step; explicit attention must also be paid to the implementation phase, or whether and how the project will be done. This paper presents the argument that not only is a positive or predictive analysis necessary to supplement the more common normative approach, but that a relatively simple conceptual extension of benefit-cost analysis can usefully apply to this task the tools that have been developed over the past few decades.

- 1.2.7 Mikesell, Raymond F. The Rate of Discount for Evaluating Public Projects. Washington, D.C.: American Enterprise Institute for Public Policy Research, 1977, 64 pp. Includes 9 pages of bibliographical references.

In an era of rapid expansion of the public sector, it is important that government officials employ methods of evaluating projects that reflect the opportunity cost of capital in the private sector. The author argues that efficient allocation of the nation's

resources for maximum social welfare requires private and public projects to be evaluated by the same standards and that these standards are best revealed in private competitive markets. The same rate of discount would serve as a common denominator for the evaluation of projects in both the private and the public sectors, assuming comparable determination of cost and benefit streams.

- 1.2.8 Mishan, E. J. Cost-Benefit Analysis: New and Expanded Edition. New York: Praeger Publishers, Inc., 1976, 454 pp.

This work is a comprehensive presentation of all aspects of social benefit-cost analysis. The book will enable the reader to ask the right questions for evaluating public investment projects. What is the social value foregone elsewhere when economic resources are channeled into a projected economic activity? What are the real effects on the consumer and the environment? Through carefully selected case studies, the various ways to allocate costs and benefits are described, drawing on present-day techniques of economic analysis, including operations research, decision theory, and game theory. These case studies illustrate the fundamental principles of benefit-cost analysis. The book includes an entirely new section on program evaluation that confronts some of the issues which frequently arise in estimating the benefits of public projects.

- 1.2.9 Peskin, Henry M. and Seskin, Eugene P., eds. Cost-Benefit Analysis and Water Pollution Policy. Washington, D.C.: The Urban Institute, 1975, 370 pp.

The major portion of this volume consists of papers presented in September 1973 at a symposium designed to determine and advance the state-of-the-art of benefit-cost analysis with special reference to water pollution policy. In addition, the editors have provided a comprehensive introduction and overview. Following this introductory material, the thirteen symposium papers and excerpts from the pertinent discussions are presented on both theoretical and applied issues relating to the measurement of benefits. Part Two contains similar material pertaining to the assessment of costs. Part Three deals with aspects of uncertainty which are relevant to benefit-cost analysis. Finally, Part Four relates the specific technique of benefit-cost analysis to the broader area of public policy.

- 1.2.10 Prest, A. R. and Turvey, R. "Cost-Benefit Analysis: A Survey." The Economic Journal, Vol. 75 (December 1965), pp. 683-735.

Although considerable work has been done in the field of benefit-cost analysis since 1965, this survey article still remains one of the most complete introductions to the field. In addition to covering the general principles of the method, the article surveys particular applications in a variety of fields: water supply projects, transport, land usage, health, education, and research. An extensive bibliography is included.

- 1.2.11 Ruegg, Rosalie T.; McConnaughey, John S.; Sav, G. Thomas; and Hockenbery, Kimberly A. Life-Cycle Costing: A Guide for Selecting Energy Conservation Projects for Public Buildings. National Bureau of Standards Building Science Series 113. Washington, D.C.: U.S. Government Printing Office, September 1978, 70 pp. Includes 25 annotated bibliographical references.

This report provides a step-by-step guide for conducting life-cycle cost evaluations of energy conservation projects for public buildings. It explains the use of life-cycle cost analysis to evaluate and rank the cost effectiveness of alternative energy conservation retrofit projects to existing public buildings, and to select the most cost-effective design for new buildings. Worksheets, illustrated with a realistic example, and a computer program are provided. This guide is compatible with a life-cycle costing guide prepared for the Department of Energy for use in the Federal Energy Management Program by Federal agencies. The purpose of this report is to provide a guide to state and local governments for use in their energy conservation programs.

- 1.2.12 U.S. Office of Management and Budget, Circular No. A-94 Revised. "Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits." March 27, 1972.

This circular prescribes a standard discount rate to be used in evaluating the measurable costs and/or benefits of government programs or projects when they are distributed over time. The prescribed discount rate of 10 percent represents an estimate of the average rate of return on private investment, before taxes and after inflation.

1.3 Benefit-Risk Analysis

- 1.3.1 Clark, Elizabeth M. and Van Horn, Andrew J. Risk-Benefit Analysis and Public Policy: A Bibliography. Report No. BNL-22285. Cambridge, Mass.: Energy and Environmental Policy Center, Harvard University, November 1976, 81 pp.

This bibliography is illustrative of the breadth of the methodologies which have been applied to examine the trade-offs between risks and benefits. The citations are divided into 26 categories, ranging from the value of human life to methods of benefit-risk analysis. There are categories dealing specifically with areas in which there are risks, such as nuclear power. One section contains citations dealing with standard setting.

- 1.3.2 Committee on Public Engineering Policy. Perspectives on Benefit-Risk Decision Making. Washington, D.C.: The National Academy of Engineering, 1972.

This is an extremely useful collection of papers presented at a colloquium sponsored by the Committee on Public Engineering Policy of the National Academy of Engineering. Summaries of the discussions and some of the recommendations are given. An extensive bibliography on benefit-risk analysis is included.

- 1.3.3 Fischhoff, B. et al. How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits. Report No. UCLA-ENG 7717. Los Angeles: Publication Services Center, UCLA School of Engineering and Applied Science, January 1977.

This study investigates a benefit-risk technique in which psychometric procedures were used to elicit quantitative judgments of perceived risk, acceptable risk, and perceived benefit for each of 30 activities and technologies. The results indicated little systematic relationship between perceived existing risks and benefits of the 30 risk items. When the unacceptably high current risk levels were adjusted to what would be considered acceptable, risk was found to correlate with benefit. Two basic dimensions of risk proved to be effective predictors of the trade-off between acceptable risk and perceived benefit. The limitations of the method and the implications of the findings for policy decisions are discussed.

- 1.3.4 Lowrance, William W. Of Acceptable Risk: Science and the Determination of Safety. Los Altos, Calif.: William Kaufman, Inc., 1976.

This book relies on real world examples and common sense approaches in its nontechnical and nonmathematical discussion of safety and risk policy problems and their history. It summarizes the ways an industrial society may methodically appraise risk, and in doing so describes how judgment and knowledge interact in the creation of safety standards.

- 1.3.5 Payne, John W. "Alternative Approaches to Decision Making Under Risk: Moments Versus Risk Dimensions." Psychological Bulletin, Vol. 80, No. 6 (December 1973), pp. 439-453. Includes 50 bibliographical references.

The literature in the area of individual decision making under risk may be characterized by two different approaches to the description of gambles. The first approach describes gambles as probability distributions over sets of outcomes. Models of decision making developed within this approach have concentrated on the means and standard deviations of the distributions as the primary determinants of risky decision behavior. The second approach describes gambles as multidimensional stimuli which may be conceptualized in terms of basic risk dimensions, such as probability of winning, amount to win, probability of losing, and amount to lose. This approach views risky decision behavior as a form of information processing. The relative merits of explanations derived from each approach are discussed. It is argued that the risk dimension approach appears more promising than that based on the mean and standard deviation of the underlying probability distribution.

- 1.3.6 Raiffa, Howard. Decision Analysis: Introductory Lectures on Choices Under Uncertainty. Reading, Mass.: Addison-Wesley Publishing Company, 1968, 309 pp. Includes bibliographical references.

The methodology presented in these lectures requires that preferences for uncertain consequences be numerically scaled in terms of utility values and that judgments about uncertainties be numerically scaled in terms of probabilities. The author discusses the intertwining concepts of utility and subjective probability, and demonstrates that these concepts are logical concomitants of some basic behavioral assumptions. The author adopts the so-called Bayesian viewpoint, which uses both utilities and subjective probabilities. After arguing

the validity of this approach throughout most of the book, he attempts to place it in a broader perspective in the final chapter, which is devoted to a brief historical account of the theory of subjective probability and an overview of the different existing schools of statistical thought.

- 1.3.7 Rowe, William D. An Anatomy of Risk. New York: John Wiley and Sons, 1977, 488 pp. Includes bibliographical references after each chapter.

This book is a comprehensive guide to the evolution and applicability of various methodologies for decisionmaking under conditions of uncertainty. It begins with a discussion of the nature of risk and factors in risk valuation and progresses to a sophisticated survey of competing methodologies that can be used in risk analysis and decision-making under uncertainty. The author stresses that the assessment of risk is as important as the quantification of risk and that the subjective perception of risk is the basis for risk assessment regardless of the objective or quantified evaluation.

- 1.3.8 Starr, Chauncey. "Social Benefit versus Technological Risk." Science, Vol. 165 (September 19, 1969), pp. 1232-1238. Includes 5 bibliographical references.

In this article the author offers an approach for establishing a quantitative measure of benefit relative to cost for accidental deaths arising from technological developments. The application of this approach leads to several conclusions regarding accepted social values relative to personal risk: (i) The indications are that the public is willing to accept "voluntary" risks roughly 1000 times greater than "involuntary" risks. (ii) The statistical risk of death from disease appears to be a psychological yardstick for establishing the level of acceptability of other risks. (iii) The acceptability of risk appears to be crudely proportional to the third power of the benefits (real or imagined). (iv) The social acceptance of risk is directly influenced by public awareness of the benefits of an activity, as determined by advertising, usefulness, and the number of people participating. (v) In a sample application of these criteria to atomic power plant safety, it appears that an engineering design objective determined by economic criteria would result in a design risk level very much lower than the present socially accepted risk for electric power plants.

1.3.9

U.S. Atomic Energy Commission, Norman C. Rasmussen, Study Director. Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants. Report No. WASH-1400. Washington, D.C., August 1974.

The Reactor Safety Study was undertaken to estimate the public risks that could be involved in potential accidents in commercial nuclear power plants of the type in use in 1974. Its objective was to make a realistic estimate of these risks and to compare them with non-nuclear risks to which our society and its individuals are already exposed. The basic conclusion of this study is that the risks to the public from potential accidents in nuclear power plants are relatively small. This conclusion is based on the finding that the non-nuclear accidents examined in this study are much more likely to occur and can have consequences comparable to or larger than nuclear accidents.

2.0 ECONOMICS USEFUL FOR STANDARDS ANALYSIS

2.1 Economics of the Standards System

- 2.1.1 American Standards Association. Company Standardization: Organization, Costs, and Savings. New York, 1959, 26 pp.

This report describes the results of a survey of 2,800 firms regarding standards work. Of the 238 respondents, 89 reported a formal organized program. Of these, 34 firms reported average dollar savings from standards of 1% of sales.

- 2.1.2 American Standards Association. Dollar Savings Through Standards: Report of Survey to Obtain Data on Savings Derived from the Use of Standards by American Industry. New York, July 25, 1956, 40 pp.

This work was compiled to demonstrate the economic benefits to American industry that could be specifically attributed to standardization. Examples of measurable savings from standardization are provided. These illustrations were prepared by some 70 American companies and 6 associations, mostly in 1955.

- 2.1.3 Chapman, Carol A. Bibliography on the Voluntary Standards System and Product Certification. National Bureau of Standards Internal Report 79-1900. Washington, D.C., October 1979, 22 pp.

This bibliography lists references accumulated by the NBS Office of Engineering Standards in the course of its research into the workings of the voluntary standards system, and the economic and legal effect of standards. The first portion of the bibliography lists references alphabetically by author. The second portion groups references by subject. Subject categories include: standards system reform, regulatory use of standards (buildings, safety, environment), certification and laboratory accreditation, solar heating and cooling, product liability, and international and foreign.

- 2.1.4 Chapman, Carol A. "How to Stop Worrying and Love Benefit/Cost Analysis." Standards Engineering, Vol. 29, No. 3 (June 1977), pp. 54-56.

Economic analysis is useful in justifying standards efforts, setting priorities for standards work, and making decisions about specific standards. In using economic analysis, some basic laws should be kept in mind: (1) There is no free lunch; (2) Something is usually forgotten; and (3) Money is a common measure

of (almost) everything. This paper shows how to apply these and some other concepts to standards-related problems. It gives hypothetical examples concerning mobile home fire safety standards and effluent measurement methods, as well as examples of actual studies conducted at the National Bureau of Standards Center for Building Technology. The latter studies involve energy conservation in buildings, reduced-sized venting, and ground fault circuit interrupters.

- 2.1.5 Crane, Garry M. Economic Effects of an Improved Measurement: A Microeconomic Approach to Technological Change. Unpublished Ph.D. dissertation, The George Washington University, February 15, 1971.

Three issues related to improved measurement are studied in this dissertation. First, a theoretical method of analyzing the economic effects of an improved measurement is developed. Second, in a case study of an improved measurement used in manufacturing stainless steel it is found that annual savings of several millions of dollars resulted. Finally, it is shown that the optimum supply of improved measurements would be provided by the private market if inventors were risk-neutral or risk-preferrers. Government is needed, however, to supervise and certify privately provided measurement systems and to reduce biases in meters used in retail sales.

- 2.1.6 Foldesi, Tamas. Economic Effects of Standardization. Geneva: International Standards Organization, 1975, 12 pp.

This work provides a general overview of 3 types of studies of the economic effects of standardization. Company studies generally involve the calculation of cost savings due to variety reduction and the consequent increased production runs. National studies involve the estimation of as many of the significant effects as possible. International studies that have been conducted focus on establishing priorities among standardization areas. Each type of study is illustrated by examples and it is noted that all methods of analysis are still in the experimental stage.

- 2.1.7 Frontard, R. "Economic Aspects of Standardization." ISO Bulletin, Vol. 18 (October 1966), pp. 441-446.

This article presents a brief analysis of tangible monetary benefits that could be derived from the

application of standardization at various stages in the manufacture of a product. A case study is conducted for a mechanical engineering firm.

- 2.1.8 Hemenway, David. Industrywide Voluntary Product Standards. Cambridge, Mass.: Ballinger Publishing Company, 1975, 141 pp. Includes 170 bibliographical references.

Except for the consideration of collusive conduct, economists have rarely analyzed industrywide activity, much less the role played by industrywide voluntary product standards and standardization in our society. This work examines this important aspect of intercompany behavior and offers, for the first time, an in-depth economic analysis of voluntary standards and standardization. Standards are classified and their benefits and costs discussed. The author shows how market structure determines both the incentives and the ability needed to create workable product standards within a given industry. The discussion includes prescriptions for public policy regarding industrywide standards. This book is the most comprehensive economic study of the U.S. voluntary standards system available to date.

- 2.1.9 Hemenway, David. Standards Systems in Canada, the U.K., West Germany, and Denmark: An Overview. NBS GCR 79-172. Prepared for the U.S. Department of Commerce, National Bureau of Standards, Washington, D.C., April 1979, 195 pp.

This report provides an overview of the voluntary standards systems of Canada, the UK, West Germany and Denmark. The immediate purpose is to identify areas where further research might be useful. Ultimately, the aim is to gain a better understanding of national standards systems in other highly industrialized countries. Based on interviews and other research, the author discusses these aspects of the four standards systems: (1) history; (2) organization and finances; (3) standards development; (4) certification and accreditation; (5) international standards work; (6) consumer and labor participation; (7) metric conversion; (8) antitrust aspects; (9) research into economic impacts; (10) the government's use of standards and its role in standards work; and (11) other activities.

- 2.1.10 Kean, John. "Benefits and Efficiencies of Standardization." Consensus (Standards Council of Canada), Vol. 3, No. 1 (January 1976), pp. 4, 5, and 12.

This brief article offers a general discussion of the benefits of standards. The Canadian Standards Association industrial safety footwear standard is cited as being very cost-effective. It was estimated that the reduction in lost manhours due to foot injuries in one province resulted in a \$3.5 million savings over a 6-year period. This represents a dollar saving 20 times the cost of developing and maintaining the standard in that province.

- 2.1.11 Matuura, S. "Measurement of the Effect of Standardization." ISO Bulletin, Vol. 20 (August 1965), pp. 305-309.

This paper proposes a method of measuring the effects of standardization in quantitative terms. The method entails computing a numerical index of the cost savings as a function of the logarithm of the ratio of index numbers representing the states of complexity before and after standardization. The estimation of the savings, however, is admittedly subjective and would be applicable only for ranking alternatives.

- 2.1.12 Melnitsky, Benjamin. Profiting from Industrial Standardization. New York: Conover-Mast Publications, 1953.

This book describes sources and uses of voluntary standards. There are detailed comments on how to operate a company standards program. Benefits to firms of various kinds of standards (classification, materials, parts, design, testing, purchasing, etc.) are also described.

- 2.1.13 Parkinson, Thomas L. "The Role of Seals and Certifications of Approval in Consumer Decision-Making." The Journal of Consumer Affairs, Vol. 9, No. 1 (Summer 1975), pp. 1-14. Includes 11 bibliographical references.

One important source of product-related information available to consumers is seals and certifications of approval. Yet little is known about the role played by these symbols in the decision-making process. This study examines the level of recognition, the perceived credibility, the perceived meaning, and the use of nine seals or certifications of approval among adult female consumers. The results would appear to have significant implications for consumer protection and education.

- 2.1.14 Phucas, Charles B. International Standards Activities: A Study of NBS Impact on International Standards Committee Activities. Washington, D.C.: U.S. Department of Commerce, National Bureau of Standards, June 6, 1975, 9 pp. Includes as one of its appendices the following report: Jack Faucett Associates, Inc. Principles and Practical Approaches for Evaluating International Standards. Report No. JACKFAU-75-136. Prepared for the National Bureau of Standards, Gaithersburg, Md., April 3, 1975, 42 pp. Includes 17 bibliographical references.

This appendix briefly outlines a conceptual framework for the economic evaluation of standards. The approach is applied in case studies of three areas of NBS international standards activities: computers, rubber and rubber products, and nuclear instruments. Two supplementary sections briefly discuss welfare changes as measured by consumer and producer surplus, as well as the welfare consequences of changes in international trade as a result of standardization. Another supplementary section provides a useful review of some works on the economics of standardization.

- 2.1.15 Poulson, Barry W., ed. Economic Analysis of the National Measurement System. National Bureau of Standards Internal Report 75-948. Washington, D.C., September 1977.

This report is a comprehensive summation of relevant work known to NBS on economic analysis of the national measurement system. It is written for a mixed audience of economists and physical scientists. The first part deals with the concept of measurement for economic analysis, the quantitative dimensions of measurement in the economy, and the relationships between measurement and economic change. The second part of the study examines the measurement system from the standpoint of the private sector, including the economic rationale for measurement by producers, consumers, and in sales transactions. The third part deals with government's role of incorporating an economic rationale for measurement activities in the public sector, and case studies of costs and benefits of activities by NBS. While none of the case studies satisfies the conditions of rigorous cost-benefit or cost-effectiveness analysis, they do provide insight into the economic role of NBS in the national measurement system.

- 2.1.16 Rawie, Carol Chapman. A Guide to Papers Citing Antitrust Cases Involving Standards or Certification. National Bureau of Standards Internal Report 79-1921. Washington, D.C., December 1979, 17 pp.

Since at least 1912, standards and certifications for products ranging from lumber to milk cans have been at issue in antitrust cases. Studying these cases may provide information about the economic effects of standards and certifications based on standards -- in particular, their impacts on competition and innovation. This paper describes several articles and reports which examine the antitrust history of standards. It is intended as a research tool to help economists and others decide which (if any) antitrust cases they should study to learn more about the economic effects of standards.

- 2.1.17 Rawie, Carol Chapman. Economics of the Product Certification Industry: Some Research Needs. National Bureau of Standards Internal Report 80-2001. Washington, D.C., 1980.

A number of private organizations certify products for safety and other qualities. With the increase in safety regulation, product liability suits, and interest in encouraging use of new technologies through certification, certification is likely to become more and more important as a way to show conformance with voluntary or regulatory standards. There have been a number of Federal and State government activities related to product certification. However, the potential impact of past and proposed government actions is not clear. One reason may be that there has been insufficient study of the economics of the product certification industry. This paper asserts that such study is needed as a basis for setting government policy and raises issues that should be addressed concerning structure and performance of the product certification industry.

- 2.1.18 Reck, Dickson, ed. National Standards in a Modern Economy. New York: Harper & Row Publishers, Inc., 1956, 372 pp.

This book is a collection of 33 articles by various authors concerning the history and effects of standardization. It focuses primarily on technical benefits of standards in a number of sectors, but also contains some qualitative comments concerning price and cost effects. A chapter by T. Richard Witmer discusses antitrust consequences of consumer goods standards and a chapter by Corwin Edwards discusses

the relationship of standards and product differentiation.

- 2.1.19 Scherer, Frederic M. "Government Research and Development Programs." In Measuring Benefits of Government Investments (edited by Robert Dorfman). Washington, D.C.: The Brookings Institution, 1965, pp. 12-70.

This paper examines the problem of measuring research and development program benefits in a nonmarket environment. Special attention is given to benefit estimates in decisions involving the trade-off between development costs and the expected time of successful completion of the program. Because much government activity in the standards area involves research and development, this article is of interest to those concerned with economic aspects of standards.

- 2.1.20 Settle, Russell Franklin and Weisbrod, Burton A. Governmentally-Imposed Standards: Some Normative and Positive Aspects. Prepared by the Department of Economics, Wisconsin University for Assistant Secretary for Planning, Evaluation, and Research, U.S. Department of Labor, Washington, D.C., June 1976, 53 pp. NTIS No. PB-256-274.

This report provides a conceptual discussion of the need for governmentally-imposed standards. These mandated standards are compared with alternative policy instruments, such as taxes and public information programs. The conditions under which standards would be preferable to these other alternatives are studied. The analysis includes both equity and efficiency considerations.

- 2.1.21 Silberston, Aubrey. The Economic Consequences of International Standardization. Document ISO/STACO (Secretariat-54) 389E. Geneva: International Standards Organization, May 1967.

This report presents a list of possible economic consequences of both national and international standards, including costs and benefits to producers, consumers, and supplying industries. The importance of the distribution of benefits and costs is noted. A particular standard may benefit some parties (e.g., the long run gains to producers resulting from a reduction of variety in production) while simultaneously resulting in a loss to others (e.g., a reduction of choice to consumers).

- 2.1.22 Spillenkothen, Roy and Renner, John. "Standardization and Industrialization: Some Thoughts on the Related Benefits, Risks and Economic Factors Inhibiting their Growth in a Competitive Economy." Industrialization Forum, Vol. 2, No. 1 (October 1970), pp. 29-40.

This article examines the introduction of standardization and industrialization, considering particularly the point of view of the building products manufacturer. Standardization affects the manufacturer's position in relation to competitors; in order to maintain some freedom to set prices, one's product must be differentiated. The typical cycle of a product's life is explained in terms of development, market establishment and growth, and finally standardization which inhibits product differentiation. Because greater profits are expected from product differentiation, the authors claim that the building products manufacturer has a vested interest that runs counter to standardization. The authors suggest that new industry structures might modify this situation.

- 2.1.23 Toth, Robert B. "The Economics of Standardization: Credits vs. Debits." Standards Engineering, Vol. 24, No. 2 (April 1972), pp. 10, 14-18, 23. Includes 12 bibliographical references.

This article describes the development of a standard that documents the general subject of cost reduction and cost avoidance. This standard was developed by the Aerospace Industries Association's National Aerospace Standards Committee and provides the means for evaluating the economic value of standardization efforts. Specific cost factors are presented as developed from industry-wide surveys and specialized sources. Several companies have applied this standard. Their results confirm the need for and the usefulness of conservative, logical and workable guidelines for deriving and defending standardization savings.

- 2.1.24 U.S. Congress, House of Representatives, Select Committee on Small Business, Subcommittee No. 5. The Effect Upon Small Business of Voluntary Industrial Standards. House Report No. 1981, 90th Congress, 2d Session, Washington, D.C., December 24, 1968, 110 pp.

The general theme of these hearings is the effect of voluntary industrial standards programs on small business. Specific attention is paid to the degree to which smaller firms are being denied minimum participation in the development of the techniques on which the standard is based, or are denied full participation in the actual writing and promulgation

of the standard itself. Possible violations of antitrust laws as well as other anticompetitive practices are also discussed.

- 2.1.25 U.S. Federal Trade Commission. Preliminary Staff Study (Precis: Self-Regulation -- Product Standardization, Certification and Seals of Approval. Washington, D.C., April 1972, 38 pp.

Industry standardization and certification programs have a large potential both for public benefit and public injury. Their benefits arise from their capacity for promoting cost-price reductions and thus improving the public's standard of living. Their costs arise from their capacity for supporting restraints of trade and consumer deception. This report contains some policy recommendations regarding these programs for the Federal Trade Commission.

- 2.1.26 Verman, Lal C. Standardization: A New Discipline. Hamden, Conn.: The Shoe String Press, Inc., 1973, 461 pp. Includes bibliographical references after each chapter.

One chapter of this comprehensive work on standardization is devoted to economic effects and the problem of their measurement. The author delineates a number of likely advantages and possible adverse effects of standards that could arise at various organizational levels of standardization (i.e., plant, industry, national, international). The chapter concludes with a discussion of several attempts to measure quantitatively the savings in production costs that result from standardization and longer production runs.

2.2 Economics of Regulation

- 2.2.1 Baram, Michael S. Federal Energy Regulation and the Use of Cost-Benefit Analysis. Prepared by Bracken, Selig and Baram for the Environmental Policy Office, Brookhaven National Laboratory, Boston, Mass., October 1, 1977, 200 pp.

This report assesses the role of cost-benefit analysis in the energy-related decision making of four Federal agencies: the Environmental Protection Agency, the Nuclear Regulatory Commission, the Energy Research and Development Administration, and the Federal Energy Administration. A case-study format is used to present findings and conclusions with respect to each agency. It is concluded that cost-benefit analysis tends to improve certain critical aspects of agency performance -- directly because of the

inherent discipline of the method, and indirectly because it promotes agency articulation of all relevant considerations and therefore enhances agency accountability.

- 2.2.2 Caves, Richard E. and Roberts, Marc J., eds. Regulating the Product: Quality and Variety. Cambridge, Mass.: Ballinger Publishing Co., 1975, 268 pp. Includes bibliographical references.

This volume contains papers presented at a workshop on the regulation of economic activity held at Harvard University. Several broad themes run through the volume. The first is the interconnection of economic and political processes. The second is the need for more detail in the theory of the firm to account for the shorter-run aspects of decision making. Without this detail, oligopolistic interaction in the area of product quality and variety cannot be sufficiently disentangled. Finally, the studies in this collection frequently reveal the endogenous nature of two forces usually considered as exogenous: the structure of markets, and the direction of public policy.

- 2.2.3 Chugh, Lal C. and Berbeco, George R. "Impact of Government Regulations on Small Firms in New England." The New England Journal of Business and Economics, Vol. 4, No. 1 (Fall 1977), pp. 33-47. Includes 12 bibliographical references.

Numerous laws pertaining to the improvement of our environmental resources, the protection of consumers, and the provision of safe and healthful working conditions for workers have been passed at the Federal and State levels since the mid-sixties. The purpose of this article is to discuss the effects of such regulations on capital expenditures, operating costs, profitability, and other operating aspects of small firms in New England. The first section of the paper describes the nature, the special provisions and the enforcement systems of these acts as they may affect small business. The second section discusses the results of a questionnaire survey of small firms with the assistance of the Small Business Association of New England.

- 2.2.4 Colantoni, C. S.; Davis, O. A.; and Swaminathan, M. "Imperfect Consumers and Welfare Comparisons of Policies Concerning Information and Regulation." The Bell Journal of Economics, Vol. 7, No. 2 (Autumn 1976), pp. 602-615. Includes 14 bibliographical references.

Consumers possess limited capacity to process technical information concerning the characteristics of products. In response, two forms of regulation commonly emerge: requirements for more understandable information about products, or restrictions on the types of products sold. This paper presents a framework for understanding and evaluating the consequences of these two forms of regulation. By using a recently developed approach to consumer theory, the authors develop a model for consumer behavior with imperfect information processing, which is then used to illustrate methods for evaluating the welfare effects of regulation.

- 2.2.5 Kahn, Alfred E. The Economics of Regulation: Principles and Institutions. 2 Vols. New York: John Wiley and Sons, 1970 and 1971.

The purpose of these volumes is to explore the contribution that economics can make to government regulation of firms. Although the primary focus is on the regulation of public utilities and the determination of a fair rate of return, the work is applicable to non-price regulation. Volume I deals with the traditional theory of economic efficiency and rules for achieving it. Volume II treats the relationship between economic performance and such institutional arrangements as market structures, incentive systems, and legal and administrative procedures.

- 2.2.6 MacAvoy, Paul W. "The Effectiveness of the Federal Power Commission." The Bell Journal of Economics and Management Science, Vol. 1, No. 2 (Autumn 1970), pp. 271-303.

This paper takes the view that the former Federal Power Commission (FPC) dispensed services that had measurable economic benefits and imposed the costs of these services on both the regulated firms and the final consumers of gas and electricity. An attempt is made to define and measure benefits from rulemaking and surveillance activities. The costs of regulatory proceedings are estimated to include expenditures of the FPC and of other participants in FPC proceedings and to include implied losses of final consumers consequent from regulatory delay. The estimates imply that the

FPC operated at a greater scale than net benefits warrant, particularly as a result of its regulation of natural gas production in the previous decade.

- 2.2.7 Peltzman, Sam. "Toward a More General Theory of Regulation." The Journal of Law and Economics, Vol. 19, No. 2 (August 1976), pp. 211-240.

This article offers a formal model of George Stigler's theory of the optimal size of effective political coalitions (see 2.2.12). The model reveals that the costs of using the political process limit not only the size of the dominant group but also their gains. This point has some interesting implications for entry into regulation and for the price-output structure that emerges from regulation. In a comment following the article, Hirshleifer argues that Peltzman wrongly assumes that regulatory politics are governed by constitutional rules. In another comment, Becker suggests that regulations that survive the keen competition for votes tend to be relatively efficient ways to redistribute resources.

- 2.2.8 Posner, Richard A. "Theories of Economic Regulation." The Bell Journal of Economics and Management Science, Vol. 5, No. 2 (Autumn 1974), pp. 335-358.

Several theories have been advanced to explain the observed pattern of government regulation of the economy. These include the "public interest" theory and several versions, proposed either by political scientists or by economists, of the "interest group" or "capture" theory. This article analyzes those theories. It argues that the public interest theory and the political scientists' versions of the interest group theory are unacceptable in their present form. The economists' version of the interest group theory is discussed at greatest length; its theoretical and empirical foundations are reviewed, and the conclusion is reached that, while promising, the theory requires both more analytical development and new sorts of empirical investigation before it can be accepted as an adequate positive theory of regulation.

- 2.2.9 Pustay, Michael W. "Industry Inefficiency under Regulatory Surveillance." The Journal of Industrial Economics, Vol. 27, No. 1 (September 1978), pp. 49-68. Includes 18 bibliographical references.

The presence of regulation may allow firms to tolerate substantial inefficiency in their operations. The extent of such inefficiency in the trunk airline industry is examined in this paper. Indices of efficiency are developed and tested for the domestic trunk airlines. The article then explores whether there are systematic and sustained differences in the measured efficiency performances of the trunk airlines. Finally, the author concludes that Peacock and Rowley's warning -- that regulation may induce inefficient resource use which would more than offset any allocative gains attributable to regulation -- cannot be dismissed as empirically unimportant on the basis of the results of this study.

- 2.2.10 Russell, M. and Shelton, R. B. "A Model of Regulatory Agency Behavior." Public Choice, Vol. 20 (Winter 1974), pp. 47-62.

This paper develops a model which predicts the behavior of regulatory agencies involved in the regulation of firms engaged in providing services under conditions of controlled entry. The analysis is based on an examination of the implications of utility maximization by three major "types" of regulators. The examination stresses the likely consequences of political coalitions and the resultant pressures placed on the regulators. Cross-subsidization is shown to be a consequence of coalition behavior and utility maximization by members of the regulatory body. The paper concludes by offering some policy recommendations.

- 2.2.11 Schmalensee, Richard. "Regulation and the Durability of Goods." The Bell Journal of Economics and Management Science, Vol. 1, No. 1 (Spring 1970), pp. 54-64.

This paper considers the production of durable goods that deteriorate at a constant percentage rate under conditions of competitive and monopoly equilibrium. A perfect market in used units of the good is assumed, as is constant returns to scale in production. It is shown that a monopolist will generally produce goods that deteriorate faster than those produced

by a competitive industry. Regulation of the durability of the monopolist's output will always cause him to increase the volume of services of the good available to the market. The author concludes that durability must be regulated if a monopolist is to be made to reproduce competitive performance.

- 2.2.12 Stigler, George J. "The Theory of Economic Regulation." The Bell Journal of Economics and Management Science, Vol. 2, No. 1 (Spring 1971), pp. 3-21.

This is a seminal article on the economics of regulation. The potential uses of public resources and powers to improve the economic status of interest groups are analyzed to provide a scheme of the demand for regulation. The characteristics of the political process which allow relatively small groups to obtain such regulation is then sketched to provide elements of a theory of supply of regulation. A variety of empirical evidence and illustration is also presented.

- 2.2.13 Weidenbaum, Murray L. "On Estimating Regulatory Costs." Regulation, Vol. 2, No. 3 (May/June 1978), pp. 14-17.

Government regulation of business is one of the growth areas of the U.S. economy. While this activity produces both benefits and costs and while they are of equal importance in judging the worth of regulatory activity, only the growth in costs is examined here. The author estimates that in fiscal year 1979, the sum of the administrative costs of Federal regulation (paid by the taxpayer) and the related compliance costs (generally passed on to the consumer in the form of higher prices) may exceed \$100 billion.

- 2.2.14 Weidenbaum, Murray L. "The Case of Economizing on Government Controls." Journal of Economic Issues, Vol. 9, No. 2 (June 1975), pp. 205-218.

This article argues that government regulation of business results in excessive costs because of waste, bias, conflicts among regulators, and concentration on trivia. Alternative solutions to the problems currently addressed by regulation are explored. Comments on this article were published in the same journal by A. T. Andersen (June 1975) and D. W. Penn (December 1975).

- 2.2.15 Wright, Charles L. "A Note on the Decision Rules of Public Regulatory Agencies." Public Choice, Vol. 31 (Fall 1977), pp. 151-155.

In recent years, economists have investigated the use of market mechanisms to deal with external diseconomies. They have also recognized that many external diseconomies cannot be compensated by internalization. When this occurs, the relevant problem becomes the specification of legal parameters for non-market regulation. This note examines one such legal parameter, namely decision rules of public agencies. The analysis is presented in formal terms using the analogy of statistical decision rules. This approach provides insight on how a change in decision rules can reverse a regulatory agency's decisions without changing its technical evaluation procedures.

2.3 Economics of Safety and Health

- 2.3.1 Blomquist, Glenn. "Economics of Safety and Seat Belt Use." Journal of Safety Research, Vol. 9, No. 4 (December 1977), pp. 179-189.

A theoretical model of life-saving activity is developed in this article. The ability of the model to predict automobile seat belt use is tested on a sample of 1800 drivers. Some of the significant explanatory variables are age of driver, male sex, and rural speed limit, all of which are positively correlated with increased seat belt use. Future labor earnings and health also significantly increase seat belt use. On the other hand, high wage rates, short trips, extra adjustment and fastening due to family demands, and lack of education tend to decrease seat belt use. A useful policy implication is that consideration of time costs (including inconvenience) is imperative in formulating any successful safety regulation.

- 2.3.2 Brown, David B. "Cost/Benefit of Safety Investments Using Fault Tree Analysis." Journal of Safety Research, Vol. 5, No. 2 (June 1973), pp. 73-81. Includes 3 bibliographical references.

This paper presents a working guide to the use of fault tree analysis to determine the benefit-cost ratios of safety investments. Fault tree analysis is a logical approach to identify the areas in a system that are most critical to safe operation. Four factors are considered when evaluating a safety alternative: (a) the severity of the accident to be

avoided, (b) the frequency of occurrence of the accident, (c) the cost of the alternative, and (d) the amount by which this alternative can reduce the expected negative utility of the accident. Comparisons of benefit-cost ratios can be made for each accident to aid in allocating the safety budget in an optimal manner.

- 2.3.3 Calabresi, Guido. The Costs of Accidents: A Legal and Economic Analysis. New Haven, Conn.: Yale University Press, 1970, 340 pp. Includes 106 bibliographical references.

This comprehensive book adopts an economic benefit-cost framework for evaluating alternative systems of accident law (e.g., fault insurance, social insurance and enterprise liability). Defining the goal of accident law as the maximum reduction of accident and accident avoidance costs that can be achieved fairly, the author examines the political and economic choices implied in various approaches to reducing these costs. Then two basic problems are discussed which all systems of accident law must face: who should be held responsible for accident costs, and how should they be valued? The author analyzes the fault insurance system now widely used and finds it wanting on grounds both of cost reduction objectives and fairness. In conclusion, he discusses recent proposals for reform of the law, points out questions they raise, and ends by indicating that a mixed system of accident law can be developed as an improvement over the fault system.

- 2.3.4 Campbell, Rita Ricardo. Food Safety Regulation: A Study of the Use and Limitations of Cost-Benefit Analysis. Washington, D.C.: American Enterprise Institute for Public Policy Research, 1974, 59 pp. Includes 5 pages of bibliographical references.

This study brings to the attention of the consumer the delicate balancing of costs against benefits and of biological risks against advantages which is often involved in public policy decisions regulating the safety of the U.S. food supply. It deals with the effect of regulation on the supply, prices, exports, and quality of U.S. food production. The report analyzes some of the basic biochemical problems involved within a framework of economic analysis. An individual case study, iron enrichment of flour and breads, is used to clarify the conceptual problems. This case study highlights several typical

scientific, economic, and ethical considerations involved in policy making in the area of food safety regulation.

- 2.3.5 Canada, John R. and Ayoub, Mahmoud A. "Economics of Safety: A Review of the Literature and Perspective." Professional Safety, Vol. 22, No. 12 (December 1977), pp. 31-38.

Economic considerations are normally at the core of safety and risk management decision-making. The decision-maker, whether in the public or private sector, must decide how to allocate scarce resources to achieve objectives. This article summarizes a broad cross section of approaches for economic decision analyses and provides references to literature on approaches and techniques for analyzing the economics of safety problems.

- 2.3.6 Cannon, James A. "Economic Analysis of Hazards." Journal of Safety Research, Vol. 6, No. 4 (December 1974), pp. 159-165. Includes 6 bibliographical references.

This paper presents a mathematical methodology for the economic analysis of hazards. The analysis consists of four parts: (1) estimation of the hazard cost, (2) estimation of the costs of various solutions to eliminate or mitigate the hazard, (3) elimination of the unfeasible solutions, and (4) determination of the optimal solution(s). Several examples of various phases of the analysis are presented, as well as a total analysis for a hypothetical industrial operation. The validity and accuracy of the estimates used in the analysis are discussed.

- 2.3.7 Cornell, Nina W.; Noll, Roger G.; and Weingast, Barry. "Safety Regulation." Setting National Priorities: The Next Ten Years (edited by Henry Owen and Charles L. Schultze). Washington, D.C.: The Brookings Institution, 1976, pp. 457-504.

This article offers a thorough survey and analysis of Federal safety regulation programs. In this context, safety regulation refers to policies that seek to prevent parties to private market transactions from taking certain risks that they would otherwise assume. Four alternatives to Federal promulgation of mandatory safety standards are analyzed: a pure market system of buyer and worker beware; a system of liability laws; a no-fault liability compensation system funded by mandatory insurance or a tax on injuries; and information programs. The authors conclude that standards are

called for in two instances: when decisions are numerous and information complex, and when the nature of the hazard is uncertain. The article recommends that the focus of regulatory efforts be switched from preventing industrial accidents to the more complex problem of reducing health hazards. Other recommendations are: that more research funds be given to the regulatory agencies; that greater reliance be placed on information programs; that Congress establish a system of fines for noncompliance; and that bounties be offered for identifying firms not in compliance.

- 2.3.8 Epple, D. and Raviv, A. "Product Safety: Liability Rules, Market Structure, and Imperfect Information." The American Economic Review, Vol. 68, No. 1 (March 1978), pp. 80-95.

In this paper, a durable good that fails randomly is considered. Failure of the good results in a loss, which consists of damages and possibly the destruction of the good itself. The safety characteristics are determined by the manufacturer. The effects of market structure and liability rules on the chosen characteristics of the good are determined. Analysis of the desirability of alternative liability rules is based on the determination of their effects on consumer welfare. Product safety and consumer welfare are shown to depend on the terms of available insurance contracts and the extent of consumers' information regarding the safety characteristics of the product.

- 2.3.9 Fromm, Gary. "Aviation Safety." Journal of Law and Contemporary Problems, Vol. 33 (1968), pp. 590-618.

This paper reviews the growth of aviation activity, estimates accident rates and costs (including the value of human life), and describes some potential measures for accident prevention. There is a discussion of a proposal to provide for no-fault compensation of aviation accident victims.

- 2.3.10 Fujii, Edwin T. "On the Value of Information on Product Safety: An Application to Health Warnings on the Long Run Medical Implications of Cigarette Smoking." Public Finance, Vol. 30, No. 3 (1975), pp. 323-332. Includes 12 bibliographical references.

This study develops the welfare economics underlying the valuation of information provided consumers on product hazards. It provides a willingness-to-pay estimate for a public good, information. The methodology is then applied to recent warnings on the

long-run medical implications of cigarette smoking. The results indicate that consumer valuation of the information provided by the Surgeon General's report on smoking and health (1964) amounted to a minimum of \$48 million per year.

- 2.3.11 Grabowski, Henry G. and Vernon, John M. "Consumer Product Safety Regulation." American Economic Review, Vol. 68, No. 2 (May 1978), pp. 284-289.

This paper analyzes the behavior and performance of the two principal agencies engaged in product safety regulation: the Food and Drug Administration and the Consumer Product Safety Commission. The authors show that the priority rankings established for regulatory efforts are clearly inconsistent with benefit-cost analysis. Product safety regulators are seen to rely solely on direct controls (product bans and standards) and to be concerned with the benefits only, as measured in the number of lives saved and accidents avoided. The authors argue that costs of controls must also be considered for efficient allocation of resources.

- 2.3.12 Hendrickson, Paul L.; McDonald, Craig L.; and Schilling, A. Henry. Review of Decision Methodologies for Evaluating Regulatory Actions Affecting Public Health and Safety. Report No. BNWL-2158UC-11. Prepared by Battelle Pacific Northwest Laboratories for the U.S. Nuclear Regulatory Commission, Washington, D.C., December 1976, 108 pp. Includes 14 bibliographical references.

This report examines several aspects of the problems and choices facing the governmental decision maker who must take regulatory actions with multiple decision objectives and attributes. Particular attention is given to the problems facing the U.S. Nuclear Regulatory Commission and to the chief concern of that agency -- the protection of human health and safety. The study examines quantitative and qualitative approaches to achieving maximum reduction in health risk at minimum implementation cost. The report concludes that rational approaches considering the value and impact of proposed regulatory actions are available.

- 2.3.13 Kunreuther, Howard and Slovic, Paul. "Economics, Psychology and Protective Behavior." American Economic Review, Vol. 68, No. 2 (May 1978), pp. 64-69.

It is argued that policy makers responsible for protecting society from natural and technological hazards need to understand the ways in which people

think about risk and uncertainty. Without such understanding, well-intended policies may not achieve their goals and, indeed, may even backfire. Because rationality is "bounded," utility theory is rejected as a guide for policy. The authors call instead for systematic empirical investigations that employ multiple methods of observation and analysis.

- 2.3.14 Lave, Lester B. "Risk, Safety, and the Role of Government." Perspectives on Benefit-Risk Decision Making (Report of a colloquium conducted by the Committee on Public Engineering Policy, National Academy of Engineering, April 26-27, 1971). Washington, D.C.: The National Academy of Engineering, 1972, pp. 96-108. Includes 14 bibliographical references.

Transportation safety is predominantly a private risk and air pollution is predominantly a public risk. This article considers these two cases in detail - including problems and suggestions for optimizing safety. Market failures relevant to safety are also catalogued, and the role of government in the safety area is examined.

- 2.3.15 Lave, Lester B. "Safety in Transportation: The Role of Government." Law and Contemporary Problems, Vol. 33 (Summer 1968), pp. 512-535.

This paper begins with a simple model of transportation safety in a society with no liability laws and no government controls on transportation but in which the individual can insure himself against certain risks. In such a society, insurance has a somewhat remarkable role, although chaos is the rule. Next, liability laws are introduced. With liability laws and insurance, individuals are encouraged to act in such a way that a more nearly optimal level of transportation safety is reached, although practical and theoretical considerations prevent such a society from achieving the optimal level of safety. The need for government action in these circumstances is then discussed. Finally, some current federal safety programs are examined.

- 2.3.16 Mellinger, Glen D. et al. "A Mathematical Model with Applications to a Study of Accident Repeatedness Among Children." Journal of the American Statistical Association, Vol. 60, No. 312 (December 1965), pp. 1046-1059. Includes 15 bibliographical references.

In this article, four sets of accident data obtained in a study of childhood accidents are used to determine how well accident liability is measured by the observed number of accidents. The authors find that

for this data the number of accidents does serve as a criterion of accident liability. It is also shown that for the number of accidents to serve well requires rigorous accident criteria, large groups from which to select accident repeater study groups, and accident histories for prospective subjects extending over long periods of time.

- 2.3.17 Oi, Walter Y. "Safety at Any Price?" Regulation, Vol. 1, No. 6 (November 1977), pp. 16-23. Includes 10 bibliographical references.

This essay provides a general overview of the economic issues of safety and its regulation. The basic premise of the author is that individuals maximize the difference between perceived benefits and perceived costs. The willingness to pay for safety (higher prices for safer products or lower wages for safer jobs) depends on the probability of an accident and the cost inflicted by the accident. The author argues that the cost of increased safety through standards and information programs should be weighed against the benefits.

- 2.3.18 Oi, Walter Y. "The Economics of Product Safety." The Bell Journal of Economics and Management Science, Vol. 4, No. 1 (Spring 1973), pp. 3-28. Includes 27 bibliographical references.

This article challenges the belief that a shift in the assignment of liability for accident costs from consumers to sellers would discourage sales of the more hazardous product grades, thereby reducing the frequency and severity of home accidents. The theory developed in this paper argues that the demand for a risky product is determined by the full price, consisting of the price of the risky good itself plus the imputed expected damage costs. The consumer maximizes utility by demanding that product grade which minimizes his full price. Under the assumptions of this model, a shift to producer liability is shown to lead to the increased production of riskier product grades. In the Autumn 1974 issue of the same journal, Goldberg criticizes Oi's assumption of full consumer information about product risks and argues in favor of product bans and liability rules as means of providing information. In the same issue, Oi responds by modifying the model to analyze the implications of imperfect consumer information concerning single-parameter product risks.

- 2.3.19 Spengler, J. J. "The Economics of Safety." Law and Contemporary Problems, Vol. 33, No. 3 (Summer 1968), pp. 619-638.

This article considers two basic questions which are fundamental to the economics of safety. The first question is how an optimal balance can be achieved between the value of varying degrees of safety and the cost of providing these degrees. The other inquiry concerns how combinations of rewards and penalties can give rise to a degree of safety that is neither excessive nor deficient but optimal in the sense that its value and cost are in balance.

- 2.3.20 Yandle, Bruce, Jr. "Products Liability, Risk and Economic Efficiency." Journal of Risk and Insurance, Vol. 41, No. 4 (December 1974), pp. 699-709.

This article analyzes certain economic effects associated with differing liability assignments between buyers and sellers. A three-actor model involving buyers, a producer-seller, and an insurance institution is developed under varying assumptions. The question of economic efficiency is approached by attempting to identify the potential gainers and losers under three possible regimes: (1) Where the buyer assumes all product liability; (2) Where the producer-seller assumes liability; and (3) Where the producer-seller removes the hazard which is the source of the risk. Finally, the movement toward producer liability is analyzed via a political-economic framework.

2.4 Valuation of Human Life

- 2.4.1 Acton, Jan Paul. Evaluating Public Programs to Save Lives: The Case of Heart Attacks. Report No. R-950-RC. Santa Monica, Calif.: The Rand Corporation, January 1973, 136 pp. Includes 10 pages of bibliographical references.

This report presents a methodology for evaluating health programs that save lives by structuring the problem as one in decision making under uncertainty and by developing a willingness-to-pay measure of the worth of the program. The procedure is designed for application to general public evaluation problems where a benefit-cost analysis is appropriate.

- 2.4.2 Akehurst, R. L. and Culyer, A. J. "On the Economic Surplus and the Value of Life." Bulletin of Economic Research (November 1974), pp. 63-78. Includes 32 bibliographical references.

In this article, it is suggested that the appropriate measure of the value of human life in benefit-cost

studies be one half of earned income plus some additional supplementary amounts to allow for transfer payments, overtime, and other features of everyday life. In advocating this measure, the authors reject the common view that earnings necessarily understate the value of life.

- 2.4.3 Bailey, Martin J. "Safety Decisions and Insurance." American Economic Review, Vol. 68, No. 2 (May 1978), pp. 295-298.

This brief paper shows how consumer choices between safety and insurance can in principle reveal a cardinal utility function unique up to a linear transformation. In the case of persons with no assets who buy insurance it is shown that the value of life implicit in safety choices exceeds discounted lifetime earnings. The lower bound for this value is a simple function of the loading charge of the insurance and the amount of insurance purchased.

- 2.4.4 Conley, Bryan C. "The Value of Human Life in the Demand for Safety." The American Economic Review, Vol. 66, No. 1 (March 1976), pp. 45-55. Includes 17 bibliographical references.

The stated purposes of this theoretical article are: 1) to extend the traditional model of individual maximization to include the effects of choices involving a changed probability of living; and 2) to determine the value of human life with reference to an individual's wealth and utility function characteristics. The major theoretical result is that for most income levels, the value of life-saving exceeds discounted lifetime earnings, so that the latter measure could serve as a lower bound for valuing human life in benefit-cost studies of safety standards. Two comments on this article and a reply were published in the September 1978 issue of the same review. Cook offers a simpler version of the same model but questions the generality of Conley's result. Jones-Lee also points out several limitations that restrict the generality of Conley's conclusion. In reply, Conley introduces the concept of subsistence income to his model to show that the value of life-saving is always greater than lifetime consumption (where consumption and income are defined net of subsistence expenditures).

- 2.4.5 Cornell, M. et al. A Survey of Methods for Estimating the Cost Value of a Human Life. Report No. CG-D-66-76. Prepared by Operations Research, Inc. for the U.S. Coast Guard, Washington, D.C., May 1976, 45 pp. Includes 14 bibliographical references.

This report presents a literature search of existing methods and philosophies for the valuation of human life. A survey is also made of various federal, state, and local agencies and organizations to determine how life valuation methods are currently being applied to make funding decisions within these organizations. The various methods and costing components defined by these surveys are compared and examined for potential application to Coast Guard benefit-cost analyses.

- 2.4.6 Ghosh, D.; Lees, D.; and Seal, W. "Optimal Motorway Speed and Some Valuations of Time and Life." Manchester School of Economics and Social Studies, Vol. 43, No. 2 (June 1975), pp. 134-143.

The paper analyzes the relationships between speed, accidents, and fuel consumption in order to reveal some of the trade-offs made by individuals and governments in their choice of speed and speed limits. A formula for optimal average speed is derived from a general model of these relationships. The model also requires estimates of the technical relationships between speed and accidents, and speed and fuel consumption. The former is estimated using a production function approach to accident causation. The mirror image of the model is also investigated by estimating the shadow prices of life and time implied by the observed average speed.

- 2.4.7 Hayzelden, J. E. "The Value of Human Life." Public Administration, Vol. 46 (1968), pp. 427-441.

This article shows that a figure for the value of human life is often required in social benefit-cost studies and outlines some of the ways in which such a calculation may be made. The main approach proposed is to base the value of life on the earnings of a typical individual and to use the same value in all studies relating to similar circumstances.

- 2.4.8 Jones-Lee, M. W. The Value of Life: An Economic Analysis. Chicago: University of Chicago Press, 1976, 162 pp. Includes bibliographical references.

This book represents a major contribution to the value of life literature. The work focuses on developing a procedure for placing a value on a lower

mortality rate resulting from increased public expenditures on safety measures. The author attempts to define the value of life in a form amenable to economic analysis and to develop a framework within which the value of life question may be answered, at both a qualitative and quantitative level. The book includes an index and an excellent review of the literature on the value of life and safety improvements and a brief exposition of several aspects of the theory of choice under uncertainty.

- 2.4.9 Linnerooth, Joanne. "The Value of Human Life: A Review of the Models." Economic Inquiry, Vol. 17, No. 1 (January 1979), pp. 52-74. Includes 41 bibliographical references.

This paper reviews four consumer maximization models where the probability of premature death enters as a variable that is both known to the consumer and under his control. These models generate a number of interesting results with respect to a person's willingness-to-pay for an increased chance of living. The most useful to the benefit-cost analyst is the derived relationship between this willingness-to-pay value and a person's lifetime earnings, and thus the relationship between the theoretically correct willingness-to-pay approach to the valuation of life-saving programs and the widely-used human-capital approach. However, the conclusions of the reviewed models are in this regard conflicting. Two of the models establish a theoretical basis for investigating the correlation of these two measures; however, this basis is shown to follow from an unrealistic assumption concerning the person's lifetime utility function. The remaining two models, although based upon more realistic assumptions, do not claim to provide theoretical grounds for making such investigations. The conclusion of this review is that in the absence of available data on personal demand for increased survival probability it is impossible to determine the relationship between the willingness-to-pay and the human-capital approaches to placing a value on human life.

- 2.4.10 Melinek, Stanley J. "A Method of Evaluating Human Life for Economic Purposes." Accident Analysis and Prevention, Vol. 6 (October 1974), pp. 103-114. Includes 32 bibliographical references.

A method of estimating a monetary value of life which can be used for the evaluation of safety precautions is presented. People are willing to spend money to reduce the risk of accidents, or alternatively to increase the probability of some benefit. The method described

endeavors to estimate the value of life which is consistent with such behavior. Examples of the application of this method are given which indicate that the value of a life is of the order of £50,000. The results obtained are compared with values given by discounted earnings. The importance of and factors influencing perceived risk are also considered.

- 2.4.11 Mishan, E. J. "Evaluation of Life and Limb: A Theoretical Approach." Journal of Political Economy, Vol. 79, No. 4 (July/August 1971), pp. 687-705. Includes 14 bibliographical references.

This article reviews the existing methods of evaluating the loss of life, or assessing an increase or reduction in accidents resulting from investment projects. The author finds that none of these methods is consistent with a basic principle of existing allocation theory and benefit-cost analysis. This principle states that a public investment represents an improvement only if at least one person is made better off and nobody is made worse off. Strict application of this principle to changes in accidents and fatalities requires a calculation of those sums which compensate each person in the community for the additional risk to which he is to be exposed. The various categories of risk which must be compensated are discussed at length. This article represents the clearest exposition of the willingness-to-pay approach to valuing human life.

- 2.4.12 Needleman, L. "Valuing Other People's Lives." Manchester School of Economics and Social Studies, Vol. 44, No. 4 (December 1976), pp. 309-342.

This paper presents valuations of changes in the risk of dying by the relatives of those at risk. What individuals will pay to reduce their relative's risk by a given amount depends on their wealth and their concern for their relative's safety. The degree of concern is defined and estimated for different relationship groups using U.S. kidney transplant data.

- 2.4.13 Rhoads, Steven. "How Much Should We Spend to Save a Life?" The Public Interest (Spring 1978), pp. 74-92.

This article provides a general survey of benefit-cost approaches to valuing life, concentrating on "willingness to pay" (WTP) and "discounted future earnings" (DFE) and their applications. The commonly used DFE approach involves calculating what future income would have been, given a normal life term. This figure is then discounted to give the value of life for the average member of the group in question. In contrast, the WTP approach tries to determine

preferences based on the willingness of individuals to pay for reductions in risk. The author argues that neither approach is completely satisfactory and that their use must be supplemented with political judgment.

- 2.4.14 Schelling, T. C. "The Life You Save May Be Your Own." Problems in Public Expenditure Analysis (edited by S. B. Chase, Jr.). Washington, D.C.: The Brookings Institution, 1968, pp. 127-162.

This is one of the first articles to discuss the value of life in terms of what individuals would be willing to pay for a reduction in the probability of death. The author considers the impact of one's death upon the economic circumstances of one's family, the impact upon the distribution and magnitude of the tax burden on society, and also the extent to which life insurance schemes provide an opportunity for individuals to share the financial losses occasioned by death. The author favors the use of direct surveys to discover what individuals would be willing to pay for a reduction in the risk of death.

- 2.4.15 Thaler, R. and Rosen, S. "The Value of Saving a Life: Evidence from the Labor Market." Household Production and Consumption (edited by Nestor E. Terleckyj). New York: Columbia University Press, 1976, pp. 265-297.

In this paper, the value of life is estimated from data on the risk premium that workers demanded for dangerous jobs. For the sample of 907 workers studied, the value of life was estimated to be about \$200,000.

- 2.4.16 Zeckhauser, Richard. "Procedures for Valuing Lives." Public Policy, Vol. 23, No. 4 (Fall 1975), pp. 419-464.

The process of valuing lives involves and reflects many of the most basic beliefs and institutions of society. The legitimacy and acceptability of the process itself may exert a significant influence on welfare. This essay argues that economists have much to contribute to the life-valuation discussion and that economics as a discipline can provide much needed organization and insight to this complex problem.

3.0 EVALUATION OF SPECIFIC DEVELOPED STANDARDS

3.1 Safety and Health Standards

- 3.1.1 Bolt, Beranek, and Newman, Inc. Technological Feasibility Assessment and Economic Impact Statement of the Proposed Beryllium Regulation. Washington, D.C.: U.S. Occupational Safety and Health Administration, April 1977, 130 pp. NTIS No. PB-268-982.

The technology feasibility, benefits, costs of compliance, and economic impact of complying with the current OSHA standard for exposure to beryllium of 2-micrograms/cu m, with the proposed 1 microgram/cu m 8-hr time-weighted average (TWA) exposure limit and with an alternate 0.5 micrograms/cu m exposure limit are examined in this report. Compliance with the current exposure level and with the proposed 1 microgram/cu m exposure limit can be achieved with existing technology; compliance with the alternate 0.5 micrograms/cu m exposure limit would require extensive adaptation of present technology, however. Incremental capital expenditures for moving to compliance with the proposed 1 microgram/cu m level are estimated to be \$6.1 to \$7.9 million.

- 3.1.2 Broussalian, V. L. "Risk Measurement and Safety Standards in Consumer Products." Household Production and Consumption: Studies in Income and Wealth, Vol. 40 (edited by Nestor E. Terleckyj). New York: National Bureau of Economic Research, 1976, pp. 491-524.

The author examines the problem of measuring risk when the primary purpose of the measurement is to decide whether a safety standard can be justified. Since the standard would be required only if the hazard was judged to be unreasonable, the author develops a criterion of reasonableness based on economic theory. This criterion is then applied to an illustrative case.

- 3.1.3 Broussalian, V. L. Considerations in the Use of Sampling Plans for Effecting Compliance With Mandatory Safety Standards. National Bureau of Standards Internal Report 75-697. Washington, D.C., June 1975, 54 pp. Includes 17 bibliographical references.

In this report, various means available to a regulator for gaining compliance with mandatory safety standards are examined. Particular attention is given to the option of mandating a sampling plan or scheme along with the standard. It is concluded that this option as well as the other identified are all viable under suitable conditions and should be available to the regulator for possible application on a case by case basis.

- 3.1.4 Dardis, Rachel; Aaronson, Susan; and Lin, Ying-Nan. "Cost-Benefit Analysis of Flammability Standards." American Journal of Agricultural Economics, Vol. 60, No. 4 (November 1978), pp. 695-700. Includes 26 bibliographical references.

This paper investigates the role of cost-benefit analysis in determining whether product safety regulations are in the public interest and applies such analysis to an evaluation of flammability standards for children's sleepwear. The results indicate the feasibility of applying cost-benefit analysis to an evaluation of safety regulations. Limitations of the study include the omission of the indirect costs of the standards and the neglect of reduced pain and suffering in the measurements of benefits.

- 3.1.5 Doern, G. Bruce. "The Political Economy of Regulating Occupational Health: The Ham and Beaudry Reports." Canadian Journal of Public Administration, Vol. 20 (Spring 1977), pp. 1-35.

This article examines the content and findings of the report of the Ham Royal Commission on health and safety of mine workers and of the preliminary report of the Beaudry inquiry into health in the Quebec asbestos industry. The reports are analyzed in relation to a case study and in the broader context of the political economy of regulating occupational health. The analysis suggests that interdepartmental jurisdictional conflicts were the main cause of past regulatory inadequacies.

- 3.1.6 Grabowski, Henry G. and Vernon, John M. "Consumer Protection Regulation in Ethical Drugs." American Economic Review, Vol. 67, No. 1 (February 1977), pp. 349-364.

This paper examines some undesirable or unintended side effects of government regulation on the structure of innovation in the pharmaceutical industry. Recent changes in the regulatory environment in ethical drugs are reviewed and shown to be a major factor leading to higher costs and risks in pharmaceutical innovation. Then significant shifts are shown to have also occurred in the structure of innovation in this industry. Namely, innovation has become more concentrated in large multinational drug firms. These firms are apparently in a better financial position to deal with the higher costs and risks of innovation and also can shift resources on a worldwide basis to offset some of the adverse impact of

regulations in this country. Some evidence concerning these international transfers is presented in the last part of the paper.

- 3.1.7 Grabowski, Henry G.; Vernon, John M.; and Thomas, Lacy Glenn. "Estimating the Effects of Regulation on Innovation: An International Comparative Analysis of the Pharmaceutical Industry." The Journal of Law and Economics, Vol. 21, No. 1 (April 1978).

A range of hypotheses to explain the declining rate of innovation in the pharmaceutical industry are proposed and analyzed based on a comparison of developments in the United States and the United Kingdom. In particular, the impact of increased regulatory controls in the United States (stemming from the 1962 amendments to the 1938 Federal Food, Drug, and Cosmetic Act) is separated from other factors by using the U.K. industry as a control. Firms in the latter country have been governed by a very different regulatory system but are similar to U.S. firms in most other ways.

- 3.1.8 JRB Associates, Inc. Economic Impact Assessment of the Occupational Safety and Health Administration's Proposed Standard for Occupational Exposure to 1,2 Dibromo-3-Chloropropane. Washington, D.C.: U.S. Occupational Safety and Health Administration, October 31, 1977, 89 pp. NTIS No. PB-278-301.

Based on information received from manufacturers and formulators of 1,2 dibromo-3-chloropropane (DBCP), governmental agencies, analytical laboratories, and suppliers of pollution control equipment, major findings and conclusions of this report are:

- (1) Compliance with the proposed standard on DBCP is technologically feasible;
- (2) The average capital cost of compliance for plants manufacturing DBCP is estimated at approximately \$1.1 million with an annual operating cost of approximately \$50,000;
- (3) The average capital cost of compliance for existing plants which formulate DBCP is estimated at approximately \$610,000 with an annual operating cost of \$12,500;
- (4) Because of the high capital cost of compliance, it is expected that many formulators will discontinue formulated DBCP, which represents only 2-4% of total sales of average formulators; thus reducing the number of plants formulating DBCP;
- (5) The total capital cost of compliance with the proposed standard is estimated to be about \$9.5 million and the annual operating cost about \$450,000; when amortized, the combined annual cost of compliance would be \$1.95 million.

- 3.1.9 Lave, Lester B. "Product Safety: An Economic View." Standardization News, Vol. 1, No. 2 (February 1973), pp. 14-21.

This article argues that the economically optimal level of safety is less than what is technically feasible; that consumers should have more freedom and information to choose among products with a range of safety; that regulatory agencies should avoid setting high minimum standards of safety for products; and that the market has generally worked quite well to incorporate the correct level of safety in products, in spite of the millions of injuries each year. A benefit-cost analysis for four automobile safety features first required in 1968 cars is used as an example of the proper decision process.

- 3.1.10 Little (Arthur D.), Inc. Technology Assessment and Economic Impact Study of an OSHA Regulation for Benzene, Volumes I and II. Washington, D.C.: U.S. Occupational Safety and Health Administration, May 1977. NTIS Nos. PB-268-862 and PB-268-863.

The technological feasibility and economic impact of the proposed OSHA regulation for exposure to benzene is assessed in this report. The potential health benefits of the proposed standard, estimated to affect 30,000 employees currently exposed above the 1 ppm level, are related to a possible reduction in the incidence of blood abnormalities including possibly leukemia. Estimated compliance costs of implementing the proposed standard for benzene are \$267.3 million for capital investment, \$124 million for first year operating costs, and \$74.3 million for recurring operating costs. The costs to industry for complying with the proposed regulation are reflected in both capital costs for engineering controls and increased operating costs related to medical surveillance, exposure monitoring, training, and record-keeping. Volume II contains appendixes covering: the potential for worker exposure to benzene in the chemical process industries; descriptions of benzene-related industries including service stations; compliance costs; and engineering controls.

- 3.1.11 Muelhause, Carl O. "A Cost/Benefit Framework for Consumer Product Safety Standards." Journal of Research of the National Bureau of Standards, Vol. 83, No. 5 (September-October 1978), pp. 459-483.

The effect of a mandated consumer product safety standard on the net public benefit is expressed in terms of the difference between two market states (pre- and

post-standard), each of which is assumed to be in static equilibrium. The analysis is facilitated by treating the post-standard state as one which can be "derived" from the pre-standard state by 1) expanding the production cost and demand functions around their initial market values and 2) introducing modifications in the production cost function required for compliance with the standard. A gain in net benefit would imply that promulgation of the standard is favorable. This approach is applied to a case study of the upholstered furniture industry, which may be subject to a certain fire prevention standard.

- 3.1.12 National Commission on Product Safety. Industry Self-Regulation: Supplemental Studies, Volume II (A Staff Report). Washington, D.C.: National Commission on Product Safety, June 1970.

Part IV of this report, "Economic Factors," contains a number of economic (mainly cost) studies of specific safety standards or programs: quality control in bottling; a safety vent for aerosol cans; substitution of tempered glass for annealed glass in buildings; hazards from rotary lawn mowers. In addition, there is a methodology for estimating costs of injuries from household products and a report on the use of cost data in planning a safety program.

- 3.1.13 Pachauri, R. K. "The Economics of Occupational Health and Safety." Journal of Safety Research, Vol. 10, No. 2 (Summer 1978), pp. 78-86.

This paper develops a theoretical framework for examining the economic effects of the Occupational Safety and Health Act (OSHA) of 1970. Relevant work done by other economists on this subject is reviewed, and a model is developed that attempts to conceptualize the decisions of a profit-maximizing firm in relation to employment levels and expenditures on safety measures. The mathematical model uses neo-classical theory to examine the effects of safety legislation both in a risk-neutral labor market and a risk-averse labor market. Some inferences on the effects of OSHA are drawn using the theoretical model derived in the paper.

- 3.1.14 Peltzman, Sam. "An Evaluation of Consumer Protection Legislation: The 1962 Drug Amendments." Journal of Political Economy, Vol. 81, No. 5 (September/October 1973), pp. 1049-1091. Includes 18 bibliographical references.

The 1962 drug amendments seek to prevent wasted expenditure stimulated by exaggerated claims for effectiveness of new drugs by requiring premarketing approval of all new drug claims by the Food and Drug Administration. This article shows that the costs of complying with this requirement have engendered a marked reduction in drug innovation. Consumer surplus analysis is then adapted and supplemented with "expert" drug evaluations to estimate the relevant benefits and costs. The main finding is that benefits forgone on effective new drugs exceed greatly the waste avoided on ineffective drugs. The estimated net impact is equivalent to a 5-10 percent tax on drug purchases.

- 3.1.15 Peltzman, Sam. "The Effects of Automobile Safety Regulation." Journal of Political Economy, Vol. 83, No. 4 (August 1975), pp. 677-725. Includes 28 bibliographical references.

Technological studies imply that annual highway deaths would be 20 percent greater without the legally mandated installation of various safety devices on automobiles. In this article, the author argues that these studies ignore off-setting effects of nonregulatory demand for safety and driver response to the devices. The author finds that those offsets are virtually complete, so that regulation has not decreased highway deaths. Time-series data imply some saving of auto occupants' lives at the expense of more pedestrian deaths and more nonfatal accidents, a pattern consistent with expected driver response to regulation.

- 3.1.16 Pennington, John and Bouland, Heber. "Evaluating Benefits and Costs of Auto Safety Standards." The GAO Review, Vol. 10, No. 4 (Fall 1976), pp. 36-42.

This article reports on a benefit-cost analysis of the auto safety features required to be introduced in the model years 1966 through 1970. Using accident data from North Carolina, nationwide estimates of the benefit-cost ratios were found to range from 0.5 to 1.9, for assumed values of a life saved of \$52,000 and \$200,000, respectively. It is suggested that the corresponding ratios for safety features introduced between 1971 and 1974 are even lower.

Limitations to the study include the fact that nationally representative accident-cause data were not available, there is a difficulty in separating benefits from different sources, manufacturers were reluctant to reveal safety feature costs and there are no universally acceptable dollar values for lives saved and injuries avoided.

- 3.1.17 Research Triangle Institute. Cotton Dust: Technological Feasibility Assessment and Inflationary Impact Statement, Parts I and II. Washington, D.C.: U.S. Occupational Safety and Health Administration, July 1976. NTIS Nos. PB-263-613 and PB-263-614.

Part I of this report contains information on the estimated benefits of control of cotton dust under the proposed standard, the feasibility of controls, implementation costs, the economic analysis of the textile industries, and the inflationary impact of the proposed standard. Part II contains six appendixes providing supplemental information and detailing the methodology used in sections of the analysis. These appendixes are: A. Cotton processing operations and technologically feasible engineering controls; B. Cost estimating procedures and detailed results; C. The cotton industry economic environment; D. Financial impacts of OSHA standard for 35 publicly-owned major textile companies; E. The input-output price model; F. NIOSH recommended standard for occupational exposure to cotton dust.

- 3.1.18 Settle, Russell Franklin. The Welfare Economics of Occupational Safety and Health Standards. Unpublished Ph.D. dissertation, The University of Wisconsin-Madison, 1974, 319 pp.

The central questions addressed by this dissertation are: (1) Under what circumstances "ought" governments to intervene in the private market's provision of occupational safety and health? (2) Given a governmental decision to intervene, under what circumstances are occupational safety and health standards the least-cost policy instrument for attaining the desired levels and types of job safety and health? The workings of the perfectly competitive, full-information model are taken as a normative benchmark for assessing the "desirability" (on allocative efficiency grounds) of governmental interventions in private occupational safety and health (OSH) decisions. Next, a framework for evaluating the social costs and benefits of governmental action to alter the private market's provision of OSH--that is, for identifying actual

market failures--is developed. Finally, the efficiency implications of two principal policy instruments for improving OSH (namely standards and tax-subsidy measures) are investigated and compared.

- 3.1.19 U.S. General Accounting Office. Need to Improve Benefit-Cost Analyses in Setting Motor Vehicle Safety Standards. Report No. B01-64497(3). Washington, D.C., July 1974. (Report to the Committee on Commerce, U.S. Senate).

This report discusses the National Highway Traffic Safety Administration's capability of making benefit-cost analyses of motor vehicle safety standards. It compares the Administration's estimate of accident costs with estimates of the National Safety Council and an Office of Science and Technology Ad Hoc Committee.

- 3.1.20 Viscusi, W. Kip. "The Impact of Occupational Safety and Health Regulation." The Bell Journal of Economics (Spring 1979), pp. 117-140. Includes 24 bibliographical references.

Occupational health and safety regulation imposes on enterprises an expected penalty that is positively related to the presence of unsafe working conditions for firms not in compliance with the standards. Higher expected penalties will increase enterprises' investment in work quality inputs, which in turn will lead workers to reduce their safety-enhancing actions. Low and moderate expected penalty levels increase health and safety, whereas very severe penalties may have a counterproductive effect. Present OSHA penalty levels are too low to create an effective financial incentive. The analysis of pooled time series and cross section data on industry health and safety investments and injury rates for the 1972-1975 period failed to indicate any significant OSHA impact for the data set analyzed.

- 3.1.21 Wu, Roland Y. "A Microeconomic Analysis of Highway Speed Limitation." Economic Inquiry, Vol. 14, No. 2 (June 1976), pp. 309-312.

This paper demonstrates that the total effect of a lower speed limit can be decomposed into two effects: A technical effect due to the greater efficiency of the automobile operated at lower speeds, and an induced effect due to the change in demand for automobile travel. The former effect is always positive, meaning a parallel change in speed and gasoline consumption. The second effect is either positive or negative, so that theoretically the direction of the total effect is uncertain.

Simulation analysis indicates that the second effect is also positive so that the speed regulation will yield a larger percentage saving in fuel than was originally anticipated from the technical effect alone.

3.2 Environmental Standards

- 3.2.1 Baumol, W. J. and Oates, W. F. "The Use of Standards and Prices for Protection of the Environment." Swedish Journal of Economics, Vol. 73, No. 1 (March 1971), pp. 42-54.

This paper proposes the establishment of a set of somewhat arbitrary standards of environmental quality (e.g., the dissolved oxygen content of a waterway will be above a specified percent at least 99 percent of the time) and then the imposition of a set of charges on waste emissions sufficient to attain these standards. While such resource-use prices clearly will not in general produce a Pareto-efficient allocation of resources, it is shown that they nevertheless do possess some important optimality properties and other practical advantages. In particular, it is proved that, for any given vector of final outputs such prices can achieve a specified reduction in pollution levels at minimum cost to the economy, even in the presence of firms with objectives other than that of simple profit maximization.

- 3.2.2 Bishop, Richard C. "Endangered Species and Uncertainty: The Economics of a Safe Minimum Standard." American Journal of Agricultural Economics, Vol. 60, No. 1 (February 1978), pp. 10-18. Includes 25 bibliographical references.

Species extinction irreversibly narrows the reservoir of potential resources. The future repercussions of this narrowing are uncertain. This paper develops the safe minimum standard (SMS) approach to public decisions involving endangered species. The SMS approach is based on game theory and calls for avoidance of extinction unless the social costs are unacceptably large. The paper also explores important linkages between the SMS approach and recent literature on preservation of natural environments.

- 3.2.3 Chugh, Lal. C.; Hanemann, M.; and Mahapatra, S. "Impact of Pollution Control Regulations on the Market Risk of Securities in the U.S." Journal of Economic Studies, Vol. 5, No. 1 (May 1978), pp. 64-70. Includes 10 bibliographical references.

The purpose of this paper is to examine the effects of the recent water and air pollution control legislation in the United States upon the stock market risk of the firms in the most directly affected industries, such as chemicals, electric utilities, iron and steel, petroleum, nonferrous metals and textiles. The results suggest that the market risk of these affected industries has increased during the Seventies--the period when EPA emission and effluent standards began to be enforced. Although the impact of each specific standard is not assessed, the study is useful in indicating the general trend of one type of impact resulting from environmental standards.

- 3.2.4 Dorfman, N. S. and Snow, A. "Who Will Pay for Pollution Control? The Distribution by Income of the Burden of the National Environmental Protection Program, 1972-1980." National Tax Journal, Vol. 28, No. 1 (March 1975), pp. 101-115.

The incidence of the burden of the federally mandated environmental protection program is measured in this article, based on cost estimates for the years 1972, 1976, and 1980. Data in the Brookings Institution's MERGE File are used to distribute the burden among households by income class. The incidence of the total burden turns out to be mildly regressive in 1972, and more regressive than a general sales tax by 1980.

- 3.2.5 Fisher, Anthony C. and Peterson, Frederick M. "The Environment in Economics: A Survey." Journal of Economic Literature, Vol. 14, No. 1 (March 1976), pp. 1-33.

This survey article provides an excellent and comprehensive review of the literature on environmental economics. Numerous bibliographical references are included.

- 3.2.6 Harrison, David, Jr. "Controlling Automotive Emissions: How to Save More Than \$1 Billion Per Year and Help the Poor Too." Public Policy, Vol. 25, No. 4 (Fall 1977), pp. 527-553. Includes 15 bibliographical references.

This paper analyzes federal policy on automotive tail pipe emissions, suggesting that the current strategy be modified to permit new car emissions

to vary for cars sold in different areas. The empirical estimates focus on a two-car strategy in which automobiles registered in polluted urban areas would continue to be subject to the strict standards mandated by the 1970 Clean Air Act, while autos registered in relatively unpolluted urban areas and rural areas would be subject to less severe standards. The author estimates that switching to a two-car strategy would save American households more than \$1 billion per year with virtually no sacrifice in air quality. Moreover, while this switch would lower the cost of emission controls for all income groups, it would work to the particular advantage of low-income households.

- 3.2.7 Harrison, David, Jr. Who Pays for Clean Air: The Cost and Benefit Distribution of Federal Automobile Emission Standards. Cambridge, Mass.: Ballinger Publishing Company, 1975, 167 pp.

An examination of the relative economic effects of the Federal auto emission standards on various groups of people. The cost of reducing emissions in compliance with the standard is treated as a form of taxation imposed primarily on car buyers. The present standards are found to be regressive in the distribution of costs among income groups. For a detailed technical summary of this work, see the book review by Timothy E. Morgan in Ecology Law Quarterly, Vol. 6, No. 4 (1978), pp. 859-868.

- 3.2.8 Kearney (A. T.), Inc. A Study to Determine the Economic Impact of Noise Emission Standards in the Construction Equipment Industry: Portable Air Compressor Report. Washington, D.C.: U.S. Environmental Protection Agency, June 1974, 285 pp. NTIS No. PB-244-307.

The scope of this study includes an analysis of the volume changes, resource costs, industry and market impacts, foreign trade impacts, individual company impacts and potential economic disruption associated with various noise emission levels for portable air compressors. The chapters of the report cover the technical and cost data base upon which the impact analysis is built, industry characteristics, baseline industry forecast, and finally, projected economic impacts for the various noise emission levels studied.

- 3.2.9 Lave, Lester B. and Seskin, Eugene P. "Air Pollution and Human Health." Science, Vol. 169, No. 3947 (August 21, 1970), pp. 723-733. Includes bibliographical references.

In this article, the effect of air pollution on human health is investigated. The authors characterize the problem of isolating health effects; they derive quantitative estimates of the effect of air pollution on various diseases and point out reasons for viewing some earlier estimates with caution; they discuss the economic costs of ill health; and they estimate the costs of effects attributed to air pollution.

- 3.2.10 Lievano, Rodrigo Joseph. Energy Use and the Environment: The Effects of Environmental Quality Standards on the Supply, Demand and Price of Fossil Energy. Unpublished Ph.D. dissertation, University of Houston, 1975, 129 pp.

An economic model is developed in this study to analyze the effects of changes in (1) resource availabilities, (2) resource prices, (3) operating environment (e.g., energy and environmental policy), and (4) patterns of energy demand, on the supply, demand, and price of fossil energy resources. The model is developed by interfacing a normative economic model of oil and natural gas supply, and an econometric demand model for the important fossil fuels and electricity, through a linear programming model of the energy conversion industries. The model is used to evaluate the economic effects of currently announced limitations on waste discharges to the water and air by industrial sources. Four cases representing different levels of restrictions on waste discharges to the water and air are evaluated for 1985 and overall results are indicated.

- 3.2.11 Little (Arthur D.), Inc. Economic Assessment of Proposed Toxic Pollutant Standards for Manufacturers and Formulators of Aldrin/Dieldrin, DDT, Endrin and Toxaphene. Washington, D.C.: U.S. Environmental Protection Agency, May 1976, 62 pp. NTIS No. PB-253-678.

This report provides an assessment of the economic impact of proposed toxic pollutant effluent standards for the manufacturers and formulators of aldrin/dieldrin, DDT, endrin, and toxaphene, based on abatement cost data supplied by EPA. The report concludes that there will be no significant adverse economic impact upon prices, sales, profitability, employment, or the end use

markets for these pesticides. The impact on prices will be potential increases of no greater than 2.3%. The assessment includes descriptions of firms, plants, and markets for these pesticides; investments and operating costs for the abatement technologies; evaluation of pricing for these products and potential adverse impacts.

- 3.2.12 Maler, K. G. "A Method of Estimating Social Benefit from Pollution Control." Swedish Journal of Economics, Vol. 73, No. 1 (March 1971), pp. 121-133.

The ideas in this article are first presented intuitively in a non-rigorous way. Then, there is a brief review of demand analysis and a statement of the marginal conditions for Pareto-optimality in an economy with public goods. A theoretical framework is developed which enables a derivation of the willingness to pay for the public control of certain types of pollution on the basis of information on demand functions for private goods.

- 3.2.13 National Academy of Sciences. Decision Making for Regulating Chemicals in the Environment. Washington, D.C., 1975. Includes bibliographical references.

This report examines principles of decision making for regulating chemicals in the environment. The intent of the study is to assess the state of the art of this type of decision making, to identify inadequacies in current methods, and to make recommendations that could aid regulatory agencies in making more equitable and scientifically sound decisions for controlling chemicals in the environment. The study is also intended to find ways to increase the information base upon which regulatory decisions are made and to develop methods of displaying the available information to make it more useful to the decision maker.

- 3.2.14 Plager, Sheldon J. et al. Economic Impact Study of the Proposed Motor Vehicle (In-Use) Noise Regulations. Chicago: Illinois Institute for Environmental Quality, May 1976, 239 pp. NTIS No. PB-255-686.

This study examines economic impacts expected to result from the establishment of proposed noise standards applicable to motor vehicles in use in Illinois. The study assesses the costs of the standards as applied to the several vehicle classes and the impact of these costs on state and local

government, and on Illinois agriculture. The potential effects on prices, employment, and industrial activity are also considered. The last section of the study reviews the anticipated benefits from noise abatement expected to be achieved by the proposed standards, provides a measure of those benefits, and compares benefits with costs on an overall basis and, for certain vehicle classes, on an incremental basis. The method for determining the amount of noise reduction expected from each of the vehicle classes is described.

- 3.2.15 Schlottmann, A. "A Regional Analysis of Air Quality Standards, Coal Conversion, and the Steam-Electric Coal Market." Journal of Regional Science, Vol. 16, No. 3 (December 1976), pp. 375-387.

Proposals have been made to prohibit the use of oil or natural gas by power plants as their primary generating fuel. There has been serious debate on the impacts on air quality of reconversion to coal. This paper investigates the possible impacts that such standards for existing power plants would have on coals with different sulfur contents and, consequently, the regional effects on the coal industry. The feasibility of placing sulfur limits directly on coal use is also considered. With these results, the implications for public policy encouraging power plant conversions to coal are investigated.

- 3.2.16 U.S. Environmental Protection Agency. Guidance Economic Analysis for the Concrete Products Industries. Washington, D.C., July 1977, 100 pp. NTIS No. PB-273-471.

The purpose of this study is to analyze the economic impact which could result from the application of alternative effluent limitation guidelines and standards of performance to be established under sections 304 (b) and 306 of the Federal Water Pollution Control Act (FWPCA), as amended. The report surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports proposal of certain effluent limitation guidelines and standards of performance based upon an analysis of the feasibility of these guidelines and standards. The investment and operating costs associated with various alternative control and treatment technologies are presented. The study supplements this analysis by estimating the broader economic effects which might result from the required application of various control

methods and technologies. This report investigates the effect of alternative approaches in terms of product price increases, effects upon employment and the continued viability of affected plants, effects upon foreign trade and other competitive effects.

- 3.2.17 Watson, W. D., Jr. and Downing, P. B. "Enforcement of Environmental Standards and the Central Limit Theorem." Journal of the American Statistical Association, Vol. 71, No. 355 (September 1976), pp. 567-574.

This analysis indicates that the source fly ash standard for coal-fired power plants is likely to be frequently violated. A model is developed that simulates emitters' reactions to key enforcement parameters. It is found that the Environmental Protection Agency's choice of policy parameters is biased in the direction of strongly inducing firms to pick pollution control devices of low collection efficiency. The article concludes that enforcement systems must account for the random sampling properties of pollution control devices and implications of certification test sampling procedures on firm behavior if effective enforcement is to be achieved.

3.3 Other Standards

- 3.3.1 Baumann, Harry and Montador, Bruce. "Government Intervention in the Marketplace and the Case for Social Regulation." (A report of the Treasury Board of Canada), Ottawa, 1977.

This paper, cited in Hemenway [2.1.9], provides an overview of four benefit-cost analyses of proposed mandatory standards conducted by economists at the Treasury Board and the Department of Consumer and Corporate Affairs. The studies, all conducted in 1977, concern insulation standards for ceilings and walls, school bus standards, safety glazing regulations, and energy consumption labeling of refrigerators.

- 3.3.2 Bergman, Edward Monroe. Toward a Standard for Eliminating Exclusionary Zoning: An Economic Analysis of Housing and Employment in Zoning Ordinances of Developing Townships. Unpublished Ph.D. dissertation, University of Pennsylvania, 1972, 405 pp.

This dissertation focuses on the growing tendency of municipalities to engage in exclusionary zoning; that is, zoning which purposely excludes lower class groups by using housing cost as a barrier and fiscal strategies which foster the commercial

and industrial tax base in order to lower residential property taxes. These aspects of zoning contribute to reduced housing and inequitable sharing of fiscal resources. This study develops and applies a performance standard for local zoning which requires the provision of housing of the type and price which can be afforded by the households of workers employed in that zone. The policy implications which might result if this performance standard were applied to developing municipalities are also analyzed.

- 3.3.3 Bucklin, Louis P. "The Uniform Grading System for Tires: Its Effect Upon Consumers and Industry Competition." The Antitrust Bulletin, Vol. 19, No. 4 (Winter 1974).

This article notes that in spite of the valuable information made available by uniform grading systems such as the one for tires, there is little consumer interest in expanding such systems. This lack of interest is attributed to the difficulty in creating readily understandable grading systems and insufficient motivation to learn the systems. The analysis also questions the compatibility of the approaches used by the consumer movement and by antitrust groups.

- 3.3.4 Fiorello, Marco and Jaffin, Stanley. Costs and Benefits of Federal Automated Data Processing Standards: Guidelines for Analysis and Preliminary Estimating Techniques. Prepared by Logistics Management Institute for the U.S. Department of Commerce, Washington, D.C., June 1978, 104 pp. Includes 87 bibliographical references.

The objectives of this report are to recommend guidelines and demonstrate a basic methodology for estimating the potential costs and benefits of automated data processing (ADP) standards. These guidelines are to assist program managers to achieve consistent and effective preparation and documentation of cost-benefit estimates for ADP standards. The report deals with the scope of a cost-benefit effort, the cost-benefit impact areas, cost-benefit analysis tools, and methods of data collection and types of data sources. The four appendixes include a reference list, a discussion of the Standards Definition Statement, a topical grouping by application area of guidelines, and an application of these guidelines to a hypothetical standard.

- 3.3.5 Fisher, W. Halder. The Economic Impact that Can be Expected to Follow the Adoption of "A Proposed Revision of Simplified Practice Recommendation 16-53 American Lumber Standards for Softwood Lumber." Prepared by Battelle Memorial Institute for the National Bureau of Standards, Washington, D.C., 1964, 68 pp.

This report assesses the economic impact of SPR-16-53, a 1964 proposal to alter the voluntary standards applied in sizing and grading softwood lumber. The first chapter orients the proposed set of standards in time; the general nature of the softwood lumber industry is examined in Chapter 2; the nature of the controversy over Proposed SPR-16-53 is taken up in Chapter 3; and the competitive effects of SPR-16-53 upon the industry are analyzed in Chapter 4. Chapters 5 and 6 are devoted to deriving and applying a partially-quantified model of the more significant competitive effects. Certain implicit results of the entire analysis are summarized in Chapter 7.

- 3.3.6 Hatos, Stephen L. U.S. Metric Study Interim Report: Commercial Weights and Measures. National Bureau of Standards Special Publication 345-3. Washington, D.C., July 1971, 109 pp.

This publication is one of a series prepared pursuant to the U.S. Metric Study Act. It explores the impacts metrication would have on commercial weights and measures activities. More specifically, the report concerns: (1) the cost of adapting or changing commercial weighing and measuring devices to record and/or indicate in metric units, and (2) the effects of metrication on state and local weights and measures jurisdictions.

- 3.3.7 Kennedy, William J. L. and Morse, Anthony. "Reducing Capital and Operating Costs through Standardization." Nuclear Engineering International, Vol. 21 (October 1976), pp. 51-53.

This article advocates the adoption of standard plant designs for nuclear power stations. Among the advantages claimed are reduced costs, shorter schedules and improved availability. The analysis stresses the importance of the use of reliability analysis to identify components and systems toward which design attention and improved maintenance procedures should be directed.

- 3.3.8 Lentz, Craig. "ASHRAE Standard 90-75 - Economic Impact on Selected Industries and the Design Profession." ASHRAE Journal, Vol. 18, No. 6 (June 1976), pp. 33-38.

The purpose of this article is to review the maximum potential loss or gain in the annual sales of selected industries based upon full implementation and enforcement of ASHRAE 90-75 as an energy conservation standard for new construction only. In addition, some comments are offered on the impact of the standard on the design profession.

- 3.3.9 Lentz, Craig. "ASHRAE Standard 90-75 - Impact on Building Energy Usage and Economics." ASHRAE Journal, Vol. 18, No. 4 (April 1976), pp. 23-28.

This study identifies the potential energy, economic, and institutional implications which could be brought about by the wide-spread adoption of ASHRAE Standard 90-75, which promotes the energy-efficient design of new buildings. The methodology and assumptions behind the study are described as they relate to ASHRAE 90's effectiveness in reducing energy consumption in selected building types. This is accompanied by discussions on the impact of ASHRAE 90 on initial investment and operating costs.

- 3.3.10 Little (Arthur D.), Inc. An Energy and Economic Impact Assessment of HUD's Minimum Property Standards. Washington, D.C.: U.S. Federal Energy Administration, October 1976, 86 pp. NTIS No. PB-266-236.

This study analyzes the various energy, economic and institutional impacts which could occur following the broad adoption of HUD's established Minimum Property Standards to cover all new residential construction. The study quantifies those impacts in the energy and economic sectors and assesses their impact in the institutional sector.

- 3.3.11 Little (Arthur D.), Inc. Energy Conservation in New Building Design: An Impact Assessment of ASHRAE Standard 90-75. Washington, D.C.: U.S. Federal Energy Administration, March 1976, 273 pp. NTIS No. PB-252-639.

This report assesses the energy, economic, and institutional impacts that may result from the broad voluntary adoption of ASHRAE Standard 90-75 by individual building regulatory authorities. This standard is the first major voluntary consensus standard dealing with energy use in new buildings and is available for optional acceptance by state and local governments. With strict use of the

Standard, annual energy consumption would be reduced in all building types and locations. This report contains many findings, observations, and recommendations concerning the effects of ASHRAE 90-75 on building energy consumption, its influences on physical changes in the buildings, its implications on the owning and operating costs of buildings, its potential impact on the nation's energy consumption in construction, its possible economic impact on several selected markets and participants within the construction sector, and its impact on building habitability.

- 3.3.12 Marshall, Harold E. and Ruegg, Rosalie T. Efficient Allocation of Research Funds: Economic Evaluation Methods with Case Studies in Building Technology. National Bureau of Standards Special Publication 558. Washington, D.C., December 1979, 47 pp.

Public and private administrators of research programs are concerned with maximizing the payoffs from their research investments; that is, with allocating their limited budgets most efficiently. Benefit-cost, rate-of-return, payback, and other evaluation methodologies are examined in this study in terms of their usefulness in helping administrators to decide whether to accept or reject research projects leading directly to applications; to plan the scale of these research projects; and to identify priorities among alternative research investments, all of which may be profitable. Data needs for applying these evaluation methodologies are outlined. The net-benefits and rate-of-return methodologies are applied to two case studies involving research in the Center for Building Technology (CBT) of the National Bureau of Standards. The first deals with a heavier asphalt shingle for roofing, and the second deals with reduced-sized venting in plumbing. The case studies show high payoffs in these two areas of research, both for society as a whole and for CBT's contribution in undertaking the research. Recommendations from the study are that research funds be allocated on the basis of anticipated payoffs determined through these evaluation techniques, and that benefit and cost data for evaluating new technologies be collected.

- 3.3.13 Marshall, Harold E.; Ruegg, Rosalie T.; and Wyly, Robert S. "Cost Savings from Reduced Sized Venting." Plumbing Engineer (July-August 1977), pp. 35-42 and (September-October 1977), pp. 45-46, 64-65.

All sanitary drain-waste-vent systems in buildings require some form of venting to protect the traps

of plumbing fixtures against failure. This article indicates that reduced sized venting (RSV), an innovative type of venting that utilizes pipes one to four sizes smaller than conventional venting permitted by existing U.S. plumbing codes, satisfies performance requirements for one and two-story houses. The report includes life-cycle cost estimates of potential savings per single-family household and for the U.S. as a whole over the next 11 years for several sets of assumptions regarding critical factors such as RSV's rate of diffusion and the discount rate.

- 3.3.14 McConnaughey, John S. An Economic Analysis of Building Code Impacts: A Suggested Approach. National Bureau of Standards Internal Report 78-1528. Washington, D.C., October 1978, 58 pp.

This report suggests an evaluation approach which can be used by building officials and legislative bodies faced with making building code decisions. A method to evaluate many of the potential benefit and cost impacts of specific building code provisions is developed. The report also defines and categorizes the economic impacts of building codes. While no approach to classifying building code impacts will be fully appropriate for all uses, the definitions and categories proposed may help to clarify or reconcile some of the differing opinions concerning the impact of building codes. Finally, the report illustrates the suggested approach by evaluating the 1975 National Electrical Code requirement for the use of Ground Fault Circuit Interrupters (GFCIs) in residences. Estimates are made of how much it costs society in order to save one life through the GFCI code provision.

- 3.3.15 McConnaughey, John S. "Economic Impacts of Building Codes." Research and Innovation in the Building Regulatory Process: Proceedings of the First NBS/NCSBCS Joint Conference, National Bureau of Standards Special Publication 473 (edited by Patrick W. Cooke). Washington, D.C., June 1977, pp. 397-419. Includes 17 bibliographical references.

This paper presents an impact evaluation approach for building officials faced with making building code decisions. Types of building code impacts are defined and categorized. A standardized method to measure and evaluate the potential benefit and cost impacts of a specific building code provision is described. The approach is intended to be a relatively simple, easy to apply system which uses available, or easily obtainable information. Benefit and cost impacts of code provisions intended to reduce the risk of death from a building hazard are examined.

The paper concludes with a case study of the 1975 National Electrical Code requirement for the use of Ground Fault Circuit Interrupters in residences.

- 3.3.16 Miller, Michael J. "The Cost Effectiveness of Medical Device Standards." Food, Drug, Cosmetic Law Journal, Vol. 31, No. 2 (February 1976), pp. 81-85.

The true cost of medical device standards can be measured in terms of the professional, industrial and governmental resources that are diverted from health care during the development of and compliance with standards. This article describes some of the major cost factors that may determine whether or not resources will be utilized effectively during the development of and compliance with standards, and whether or not resources will be utilized effectively in a way which maximizes device safety and effectiveness without undue loss of innovation. The author raises serious questions as to whether or not medical device standards will be an effective form of regulation in the near future. Because the relative benefits and costs of medical device standards are unclear, the author argues that the FDA should proceed cautiously in utilizing standards as a regulatory mechanism.

- 3.3.17 Mitchell, Robert Edward. "Cultural and Health Influences on Building, Housing, and Community Standards: Cost Implications for the Human Habitat." Human Ecology: An Interdisciplinary Journal, Vol. 4, No. 4 (October 1976), pp. 297-330. Includes 5 pages of bibliographical references.

International research and practices are reviewed in this article with regard to cultural, social, economic, health, and physical-technological features of needs, standards, and codes regulating the residential environment. Housing and building codes, as well as zoning and subdivision ordinances, are influenced by nonscientific considerations that have significant cost and other policy implications. These influences are examined for public health codes regulating potable water, waste disposal, and safety in the home, as well as density and congestion for cities, neighborhoods, and individual dwelling units. Cost-benefit ratios indicate that many standards can be appreciably lowered.

- 3.3.18 National Center for Productivity and Quality of Working Life. The Uniform Tire Quality Grading System: A Case Study of the Government Regulatory Process. Washington, D.C., 1978, 56 pp.

The long saga of the attempt by the Federal government to help the American consumer to buy tires more intelligently began in January 1964, when the Senate Subcommittee on Retailing, Distribution, and Marketing Practices recommended the establishment of a consumer information system similar to that in the meat industry. Despite enactment of the National Traffic and Motor Vehicle Safety Act in 1966, which required that a tire quality grading system go into effect no later than September 9, 1969, there is today still no such system. This report attempts to explain why such an apparently straightforward task has taken 13 years, and it aims to draw some conclusions from this episode about the government regulatory process.

- 3.3.19 Oster, Sharon and Quigley, John M. "Regulatory Barriers to the Diffusion of Innovation: Some Evidence from Building Codes." Research and Innovation in the Building Regulatory Process: Proceedings of the First NBS/NCSBCS Joint Conference, National Bureau of Standards Special Publication 473 (edited by Patrick W. Cooke). Washington, D.C., June 1977, pp. 113-135. Includes 22 bibliographical references.

Previous studies have suggested that outmoded local regulation of residential construction has impeded technical progress in the industry. This paper attempts to identify the determinants of differences in building regulation across communities. Research results indicate that the education of the chief building official and the level of unionization in the area are the two major factors explaining the probability that a jurisdiction will adopt a construction innovation in its code.

- 3.3.20 Slome, Benjamin. Computer Technology and Standardization in U.S. Trade and Production Abroad: A Case Study of the Vernon Product Cycle Model. Unpublished Ph.D. dissertation, The City University of New York, 1972, 148 pp.

This dissertation contains an interpretation and case study of the model presented by Raymond Vernon in "International Investment and International Trade in the Product Cycle," Quarterly Journal of Economics, May 1966, pp. 190-207. The product that is the subject of the case study is the digital computer. The author finds that for the most part the Vernon model was successful with regard to its focus upon the international activities of multinational firms within the dynamic context of a product cycle.

The study, however, also indicates that Vernon's approach to international economic analysis would be improved by eliminating its present reliance upon unwieldy product standardization concepts.

- 3.3.21 U.S. Department of Commerce, National Bureau of Standards. A Cost Benefit Analysis of Proposed Federal Input/Output Channel Level Computer Interface Standards. National Bureau of Standards Internal Report 78-1487. Washington, D.C., June 1978, 32 pp. Includes 11 bibliographical references.

This report summarizes the results of an analysis of the cost savings that are expected to accrue to the Federal Government through use of four proposed Federal input/output channel level computer interface standards. The analysis is based on the best available data, and the results are intended to be a best conservative estimate of the potential Federal Government cost savings that will occur through use of the proposed interface standards to increase competition in the procurement of computer peripheral equipment. The analysis concludes that the Federal Government will obtain cost savings through use of this standard of over \$55 million during the 5-year period beginning in FY 1979.

- 3.3.22 U.S. National Highway Traffic Safety Administration. The Automotive Fuel Economy Standards for Model Year 1981-1984 Passenger Cars. Washington, D.C., June 1977, 141 pp. NTIS No. PB-275-827.

This study evaluates various micro- and macroeconomic impacts of the average fuel economy standards for model year 1981-84 passenger cars. Such microeconomic impacts as cost and price changes for both the domestic manufacturers and the consumer are analyzed. Also examined are such macroeconomic impacts as employment, energy consumption and G.N.P.

4.0 ECONOMICS APPLIED TO THE DEVELOPMENT OF STANDARDS

4.1 Fire Standards

- 4.1.1 Chapman, Robert E. "Cost-Effective Methods for Achieving Compliance to Fire Safety Codes." Fire Journal, Vol. 73, No. 5 (September 1979), pp. 30-39, 123. Includes 4 bibliographical references.

This article discusses the use of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards for determining equivalence to the Life Safety Code. The Life Safety Code, a voluntary code developed by the National Fire Protection Association, is currently the most widely used guide for identifying the minimum level of fire safety in buildings. This paper briefly describes: the Fire Safety Evaluation System; a computerized procedure based on this system which permits identification of the least-cost means of achieving compliance to the 1973 Life Safety Code; and the results of the application of this procedure to a typical 300 bed general hospital.

- 4.1.2 Chapman, Robert E.; Chen, Philip T.; and Hall, William G. Economic Aspects of Fire Safety in Health Care Facilities: Guidelines for Cost-Effective Retrofits. National Bureau of Standards Interagency Report 79-1902. Washington, D.C., 1979, 103 pp.

This study focuses upon one aspect of the fire safety problem in health care facilities; the use of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards for determining equivalence to the Life Safety Code. The Life Safety Code, a voluntary code developed by the National Fire Protection Association, is currently the most widely used guide for identifying the minimum level of fire safety in buildings. Using the Fire Safety Evaluation System as a basis, this study develops a computerized procedure which permits the least-cost means of achieving compliance to the Life Safety Code in health care facilities to be identified. Since each of the parameters used in the Fire Safety Evaluation System has a unique value which corresponds to strict compliance, it is possible to quantify the cost savings attributable to the use of the Fire Safety Evaluation System over strict compliance to the Life Safety Code. Preliminary studies of a prototypical hospital indicate that the use of this computerized procedure can result in cost savings of 50 percent or more over those associated with strict compliance to the Life Safety Code.

- 4.1.3 Chapman, Robert E.; Hall, William G.; and Chen, Philip T. A Computerized Approach for Identifying Cost-Effective Fire Safety Retrofits in Health Care Facilities. National Bureau of Standards Interagency Report 79-1929. Washington, D.C., 1979, 114 pp.

This report focuses on how a computerized version of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards can be used to determine equivalence to the Life Safety Code in the least costly manner. The study presents a programmer-oriented discussion of the mathematical, economic and engineering considerations that went into the development of the linear programming algorithm for identifying cost-effective retrofits. Topics treated in this report include: a discussion of user options; program documentation; format statements; flow charts; sample computer runs; and a complete listing of the computer program.

- 4.1.4 Craw, Alexander R. Analyses for Decision in the Office of Flammable Fabrics: The Level of the Standard. National Bureau of Standards Internal Report 73-182. Washington, D.C., April 1973, 66 pp.

This report analyzes the level at which a particular standard for flammable fabrics should be set. Attention is focused on the children's sleepwear problem, and the methodology used is that of decision analysis. Initially, this approach identifies the alternative levels for which a choice must be made, then proceeds to an identification of the outcomes to be considered. Then a determination of the probabilities of the possible outcomes is made by introducing auxiliary variables. The paper concludes with a summary discussion of the present work in setting standard levels and recommendations for future work.

- 4.1.5 Dardis, Rachel and Thompson, Ruth. "Strategies for Reducing Residential Fire Losses." Journal of Consumer Product Flammability, Vol. 6, No. 2 (June 1979), pp. 136-151. Includes 16 bibliographical references.

In this article, the net benefits from two alternative fire reduction strategies are considered. The first strategy is the proposed standard for upholstered furniture while the second strategy is the installation of smoke detectors in residential homes in response to state or local requirements. Costs and life-cycle benefits are estimated for a single year (1980) and for a ten-year period 1980-1989. The results indicate that

the smoke detector requirement is a cost effective strategy compared to the proposed mandatory standard for upholstery furniture. A brief summary of this article may be found in Rachel Dardis and Ruth Thompson, "Analyzing the Effectiveness of Alternative Fire Protection Strategies," Fire Journal (September 1979), pp. 7-10.

- 4.1.6 Helzer, Susan Godby; Offensend, Fred L.; and Buchbinder, Benjamin. Decision Analysis of Strategies for Reducing Upholstered Furniture Fire Losses. National Bureau of Standards Technical Note 1101. Washington, D.C., June 1979, 138 pp. Includes 29 bibliographical references.

Decision analysis is used to evaluate alternative strategies for reducing residential upholstered furniture fire losses. Three alternatives are evaluated: no-action, mandatory smoke detector installation, and the proposed upholstered furniture standard under consideration by the Consumer Product Safety Commission. Quantitative models are developed to assess fire losses and costs under each alternative. The alternatives are evaluated on the basis of minimizing the total cost plus loss to society over time. Subject to the assumptions set forth in the report, the analysis shows that the detector alternative and the proposed standard are essentially equivalent and preferred to the no-action alternative. The proposed standard is more effective in saving lives, whereas the detector alternative is less costly to implement. The sensitivity of the results to key assumptions and input parameters is tested. The results are shown to be particularly sensitive to the cost of the proposed standard, the loss of life value assignment, and the upholstered furniture replacement pattern.

- 4.1.7 Lie, T. T. "Economic Design for Fire Safety." Build International, Vol. 7, No. 4 (July/August 1974), pp. 289-304. Includes 8 bibliographical references.

A method is discussed by which the fire loss expectation for buildings, both life and property losses, can be evaluated. The influence of various factors such as building size and height, installation of sprinkler and detection systems, and fire resistance of the building are shown. An example is also given of how, in principle, optimum fire safety measures can be determined. Fire safety measures are regarded as optimum if: (1) they provide an adequate level of safety to people, here assumed to be equivalent to a certain specified loss expectation;

and (2) the sum of property loss expectation and expenditures for fire safety measures is minimized.

- 4.1.8 Smith, Betty F. and Dardis, Rachel. "Cost Benefit Analysis of Consumer Product Safety Standards." The Journal of Consumer Affairs, Vol. 11, No. 1 (Summer 1977). Includes 27 bibliographical references.

This article investigates the role of benefit-cost analysis in evaluating consumer product safety standards and applies such analysis to an evaluation of flammability standards for children's sleepwear. The cost of safety standards includes the costs of standard development and enforcement and the changes in producer and consumer surpluses due to product regulation. The benefits from safety standards are the reduction in product accidents and the direct and indirect costs of such accidents. The cost of the 0-6X Children's Sleepwear Standard was based on the change in consumer surplus since it was assumed that supply was perfectly elastic. The benefits were due primarily to the reduction in burn injuries: Cost-benefit ratios ranged from 0.62 to 0.84 assuming that the standards provided 100% protection. No allowances were made for the reduction in consumer choice nor for pain and suffering avoided.

4.2 Energy Conservation Standards

- 4.2.1 Heim, Warren P. Insulation Standards for Vermont Residences. Report No. DVE-7. Hanover, N.H.: Thayer School of Engineering, Dartmouth College, January 1975, 35 pp. Includes 13 bibliographical references.

Residential insulation standards for the State of Vermont are developed in this study using optimum insulation amounts based on long-term projected energy prices and late 1974 construction prices. A form that a homeowner can fill out to determine how much energy could be saved if his house were well insulated is developed. The form is based on the aforementioned standards and can be used in a survey to see if such standards are actually necessary.

- 4.2.2 Hirst, Eric and Carney, J. Energy and Economic Effects of Residential Energy Conservation Programs. Oak Ridge, Tenn.: Oak Ridge National Laboratory, 1977, 7 pp.

A detailed simulation model of residential energy consumption is used to evaluate energy usage and the direct economic effects of several conservation programs including thermal standards for new

construction. Research results indicate that standards could save energy and money; estimates of both types of savings are given and analyzed for each program.

- 4.2.3 Marshall, Harold E. and Petersen, Stephen R. "Economics and the Selection and Development of Energy Standards for Buildings." Energy and Buildings, Vol. 2 (1979), pp. 89-99. Includes 12 bibliographical references.

Energy conservation standards for new buildings will play a major role in federal and state conservation policies in the coming decade. This article discusses economic efficiency considerations that can be incorporated into the selection and development of such standards. Three types of energy budgets--fixed energy budgets, partially variable energy budgets, and economically efficient energy budgets (EEEB)--are examined for use as standards. Research and operational requirements for developing and implementing energy budgets are described. The three energy budget standards are evaluated in terms of economic efficiency, administrative feasibility, equity, and consistency in design requirements. The EEEB appears optimal in that it ranks highest overall with respect to these four criteria.

- 4.2.4 Marshall, Harold E. and Ruegg, Rosalie T. "Energy Conservation through Life-Cycle Costing." Journal of Architectural Education, Vol. 30, No. 3 (February 1977), pp. 42-51.

This article provides cost information concerning alternative energy conservation designs for old and new buildings. Specifically, it deals with the cost over time of introducing energy conservation techniques as compared with the cost savings over time from reduced energy bills. The article examines retrofitting existing residential buildings for energy conservation, the design of envelope features and subsystems for new building energy conservation, and energy standards for buildings, all in terms of life-cycle cost (LCC) analysis. The study also gives an overview of methods for estimating the LCC of alternative energy conservation techniques.

- 4.2.5 Petersen, Stephen R. The Role of Economic Analysis in the Development of Energy Standards for New Buildings. National Bureau of Standards Interagency Report 78-1471. Washington, D.C., July 1978, 38 pp.

The Federal Government and a number of states are currently developing energy conservation standards

for new buildings. This report suggests that economic considerations be incorporated directly into this standards development process. A life-cycle benefit-cost approach to standards development can provide a systematic and objective framework for standards specification. Differences in climate, building type, energy cost, and operational requirements can be directly incorporated into the standard as they affect energy-related benefits and costs. The study shows that the life-cycle costs associated with any given overall conservation goal can be reduced by developing an economically balanced standard. In addition, it suggests that a standard which has as its goal the minimization of life-cycle costs will likely lead to greater effective energy savings than alternative approaches. Specific suggestions for the incorporation of economic analysis into the standards development process are made.

- 4.2.6 Prais, S. J. "The Electric Lamp Monopoly and the Life of Electric Lamps." Journal of Industrial Economics, Vol. 23, No. 2 (December 1974), pp. 153-158.

This article presents an economic analysis of the British standard of 1000 hours for the life of the electric light bulb. The author derives an optimization rule which states that the least-cost life depends on the ratio of the replacement cost to the operating cost per unit of time. Indeed, the optimal life is approximately nine times this ratio. The 1000-hour standard life is criticized on two counts: (1) It is generally too short; and (2) it should not be the same for all wattages, but rather should be longer for larger-watt bulbs. This methodology could be used to develop economically optimal standards for light bulbs.

- 4.2.7 Weber, Stephen F. "Economic Analysis of Alternative Envelope Designs for New Residences in the United States." Energy: The International Journal, Vol. 5, No. 1 (January 1980), pp. 63-68. Includes 7 bibliographical references.

An economic evaluation is conducted for selected energy-conservation investments in the envelope design of new single-family housing in the U.S. Alternative investment levels in the four major components of the building envelope are evaluated: (1) attic, (2) walls, (3) floor, and (4) windows. The analysis is conducted for five cities of widely diverse climate conditions and for the major forms of energy used for heating and cooling in the U.S. For each investment level, the internal rate of

return (IRR) is calculated on an incremental basis, that is, in comparison with the next lowest level of investment for that component. This marginal IRR is used to rank alternative levels of investment for all four components so that economically optimal envelope designs can be selected for each city and energy type. Two points of view are considered in the selection of optimal designs: that of an individual home-buyer and that of a public policy planner.

- 4.2.8 Weber, Stephen F. "Resource Impact Factors and Optimal Energy Conservation Standards for Buildings." Energy and Buildings, Vol. 1, No. 2 (October 1977), pp. 117-130. Includes 13 bibliographical references.

The effects of using "Resource Impact Factors" (RIFs) in the determination of an optimal energy conservation performance standard for buildings are assessed in this article. RIFs may be generally defined as indices constructed to reflect the full social costs of using various energy types. The major elements which RIFs should take into account are discussed as well as the appropriate method of formulating them. A cost minimization model for determining the optimal standard is used in conjunction with a range of RIF values so that a comparison can be made between a standard that is optimal from the private point of view (without RIFs) and one that is optimal from the social point of view (with RIFs). The comparison is made in terms of the amount of energy saved by each standard in climates of differing severity.

- 4.2.9 Weber, Stephen F. The Effect of Resource Impact Factors on Energy Conservation Standards of Buildings. National Bureau of Standards Building Science Series 114. Washington, D.C.: Government Printing Office, 1978. Includes 28 bibliographical references.

This report addresses the question of the proper value for energy to be used in the development of optimum (i.e., cost-effective) energy conservation performance standards for buildings. This study finds that the appropriate value for energy is its social value, which should be determined through the development and application of Resource Impact Factors (RIFs). Some guidelines are provided for the formulation and development of RIFs. A life-cycle cost minimization model for determining the optimum conservation standard is employed to show how the use of RIFs would generally lower the maximum allowable energy consumption allowed by the standard, although this effect steadily diminishes

as the RIF value increases. Moreover, the additional energy savings resulting from using RIFs are shown to increase as the severity of the climate increases. Finally, geometric and algebraic measures are derived for the net gain in economic efficiency that would result from using RIFs in developing energy conservation performance standards.

4.3 Other Standards

- 4.3.1 Chapman, Robert E. and Colwell, Peter F. Economics of Protection Against Progressive Collapse. National Bureau of Standards Internal Report 74-542. Washington, D.C., September 1974, 35 pp.

Public and government concern about the progressive collapse of buildings caused by abnormal loading has resulted in the development of draft standards to provide protection against progressive collapse. From society's viewpoint, standards for protection against progressive collapse should result in a level of protection which is more efficient (i.e., the net social benefits from protection should be increased). An economic model utilizing the principles of benefit-cost analysis is developed which establishes a methodology for determining the efficiency of various levels of protection against progressive collapse. An application of the model to a partial evaluation of a specific standard demonstrates some of the capabilities of the model. Recommendations are made for a complete evaluation of this standard and for the further refinement of the model.

- 4.3.2 Clark, Roy E. and Roat, Candace L. Metrication and Dimensional Coordination: A Selected Bibliography. National Bureau of Standards Special Publication 458. Washington, D.C., April 1977, 36 pp.

The United States changeover to the use of the SI (international metric) measurement language presents our construction industry with the need to review and adapt many product standards and practices for the use of metric measurement units. These adaptations and changes can bring substantial benefits to the industry in the form of permanently recurring cost savings. A practice of potentially great benefit would be the incorporation of dimensional coordination in the new metric standards for sizes of building products. For such benefits to be realized, however, the involved issues must be effectively addressed and the requisite decisions made and implemented. This report aids construction industry consideration and resolution of metrication decisions by providing a guide to the best available sources relevant to the issues.

- 4.3.3 Crouch, Robert L; Eckert, Ross D.; and Rugg, Donald D. Monitoring Groundwater Quality: Economic Framework and Principles. Santa Barbara, Calif.: General Electric Company, September 1976, 107 pp. NTIS No. PB-260-919.

This report discusses the economic considerations in selecting an optimal groundwater quality monitoring system. Section I argues that poor specification of the property rights in groundwater is a major cause of excessive pollution. Section II examines groundwater adjudication and legislation and notes that government intervention through the authority of PL 92-500 will take the form of government-established and -enforced groundwater quality standards. Section III discusses the overall costs and benefits to society involved in groundwater quality monitoring. Section IV discusses monitoring needs for the establishment of quality standards and their enforcement, and develops a benefit-cost framework for the analysis of groundwater quality monitoring. Section V examines an alternative regulatory approach based on "waste relocation rights" for property owners. These rights would protect property owners' groundwater from pollution by others through specifying allowable pollutant levels. They would be transferable in the marketplace (like mineral rights) and enforcement of them would be carried out in the courts.

- 4.3.4 Hyden, John William. A Computer Simulation Analysis of Surface Water Quality Management Policies Under Dynamic Economic and Hydrologic Conditions. Unpublished Ph.D. dissertation, Clemson University, August 1973, 304 pp. NTIS No. PB-243-842.

The purpose of this study is to determine the optimal economic wastewater treatment standards for individual users in a river basin. The specific case used in this study consists of a series of firms located along a river, such as municipalities, wet process industries, or recreational facilities, which have the river as their only source of raw water supply, and as the ultimate discharge point of their wastewater. The economically optimal wastewater treatment standards are defined as the minimization of the sum of costs imposed on the individual users for wastewater treatment and of those resulting from damages caused by waste discharges of the upstream users. It is shown mathematically that the optimum occurs when, for all users, the marginal treatment cost equals the sum of the respective downstream marginal damage costs. Analyses of the effectiveness of a given water quality management policy in maintaining

reasonable economic efficiency as various conditions change are presented in a prototype, computer simulation program, in order to consider such an approach in river basin planning activities.

- 4.3.5 Jacoby, Henry D. and Steinbruner, John D. Clearing the Air: Federal Policy on Automotive Emissions Control. Washington, D.C.: National Science Foundation, 1973, 223 pp. NTIS No. PB-263-937.

This study reviews the history of the federal efforts to control automotive emissions, and surveys the existing knowledge about the technical issues that loomed so large. Various policy options are developed and an attempt is made to evaluate each in terms of possible outcomes. It explores some of the barriers to speedy adoption of advanced engine designs, and plots the details of a plan for implementing the more desirable emissions control policy. Two chapters consider many of the details that must be taken into account in an analysis of automotive control policy and its expected outcome. Chapters 6 and 7 present a set of outcome calculations in the dimension of health effects. Chapter 8 develops an analytical structure for estimating the benefits to health of marginal changes in emissions standards and presents some preliminary estimates.

- 4.3.6 Stollman, Jeffery et al. Economic Impact Analysis of Anticipated Hazardous Waste Regulations on the Industrial Organic Chemicals, Pesticides, and Explosives Industries. Washington, D.C.: U.S. Environmental Protection Agency, January 1978, 291 pp. NTIS No. PB-279-645.

This report presents an analysis of the economic impacts of alternative regulatory levels for hazardous waste management in the industrial organic chemicals industry. The analysis consists of three segments: Industry Profile, Price Effects Analysis, and Economic Impact Analysis. The Industry Profile delineates the products, producers, and plant characteristics in the industry. It also includes a discussion of sales trends, innovation, and industrial organization of the various industry subcategories. The Price Effects Analysis discusses the pricing practices in the various industry segments, and includes estimates of product price elasticity where available. The Economic Impact Analysis delineates the impacts of two levels of regulation on the following: industry capital availability, industry entry and exit, industry structure, product prices, general inflation, GNP, foreign trade, regional economics, employment, and national energy use.

4.3.7 Voornees (Alan M.) and Associates, Inc. An Analysis of the Economic Impact of Motor Vehicle Use Restrictions in Relation to Federal Ambient Air Quality Standards. McLean, Va., September 1973, 76 pp. NTIS No. PB-227-923.

The major purpose of this study is the development of a cost-effectiveness methodology for evaluating transportation control strategies as a means of achieving ambient air quality standards, using Baltimore and Boston as case studies. The main body of the text concentrates on the methodology, leaving discussion of how the estimates of the emission reductions, costs, and benefits were formed to the technical appendix. The methodology presented calls for the explicit identification of air pollution reductions potential of alternative control strategies as well as the costs incurred by public agencies, users, and other groups of interest. The costs and effects are presented in graphic form which clearly indicates the relative average cost per unit of emission reduction for each alternative, thereby making it possible to order the strategies in terms of desirability on the basis of cost-effectiveness.

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